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ROTATORY DISPERSION OF AMMONIUM SALT OF D-CAMPHOR—β—SULPHONIC ACID

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SUMMARY

The ammonium Salt of D-and L-camphor-β—sulphonic acid have been prepared and characterised. Their rotatory power in water, methyl alcohol and ethyl alcohol has been studied and it has been found that they exhibit simple dispersion. The salts do not show any appreciable mutarotation in non-aqueous solvents.

INTRODUCTION

D—Camphor-β-sulphonic acid or Reychler's acid[1] is a strong monobasic acid and forms salts easily with bases. It has been extensively used for the resolution of numerous organic bases. In all such resolutions the sulphonic group of the acid usually combines with the amino group of the base to yield diasterioisomers with different solubilities. These diasterioisomers are ammonium type of salts. The simplest of all such compounds would be the ammonium salt. The ammonium salt of Reychler's acid had previously been prepared by Pope and Gibson[2] and by Graham[3]. These authors also recorded the optical rotation of Ammonium-D-Camphor-β-sulphonate for sodium light in water. One of us (O. N. P.) had previously prepared and studied[4] its optical rotatory dispersion in aqueous solution. Schreiber and Shriner[5] have prepared several primary amine salts of Reychler's acid. They found that these salts underwent slight mutarotation in non-aqueous solvents. In aqueous solvents, however, no mutarotation was observed owing probably to the rapidity with which the ketimine transformation of the type suggested by the authors might take place in water. In the present paper the authors have studied the rotatory dispersion of ammonium-D-camphor-β-sulphonate in both aqueous and non-aqueous solvents.

According to the Pasteur's Principle of Molecular-Dissymmetry the dextro- and the laevo-forms of a compound must possess identical scalar properties. Some doubt has been thrown on the validity of this principle by Campbell[6]. Others[7], however, have found no difference in the scalar properties of enantiomorphs which was not within experimental error. In this paper the authors have also prepared and studied ammonium-L-camphor-β-sulphonate and compared its properties with those of the corresponding D-isomer.

EXPERIMENTAL

D-Camphor-β-sulphonic acid.

The acid was prepared essentially by the method of Reychler[1]. Natural D-camphor manufactured by The China Camphor Co., Hong Kong, was used.

20 *g*. of concentrated sulphuric acid and 40 gm. of acetic anhydride was separately cooled in ice and then mixed. To this cold mixture was added 30 gm. of powdered camphor in small amounts at a time. The mixture was allowed to stand for 24 hours at room-temperature when the crystals of D-camphor-β-sulphonic acid were deposited. They were then filtered at the pump over glass wool. They were recrystallised from alcohol and moisture free ethyl acetate and dried in vacuum over anhydrous calcium chloride.

Yield of the purest product = 16 *g*.

Melting-point............ = 197-98° *d*.

$$\left[M\right]_D^{15°} = +53{\cdot}38° \text{ in water}$$

L-Camphor-β-sulphonic acid.

For this purpose L-camphor was prepared by the oxidation of L-*iso*-borneol.

20 *g*. of L-*iso*-borneol was dissolved in a mixture of 75 ml. nitric acid (density=1.32) and 4.8 ml. of sulphuric acid (50%) and heated on water-bath for 10 Hours at 80-90° C with frequent shaking. The resulting product was poured over ice cold water when camphor was precipitated. It was filtered and treated with 3.5 g. of sodium hydroxide in aqueous solution along with 4-5g of potassium-permanganate. It was then steam distilled. The product was further purified by crystallisation from aqueous alcohol.

The L-Camphor-β-sulphonic acid was then prepared by sulphonation of this camphor in a manner similar to that given for D-Camphor-β-sulphonic acid above.

Ammonium-D-camphor-β-sulphonate.

6g. of D-Camphor-β-sulphonic acid was taken in a dish and neutralised by excess of ammonia. The whole was then evaporated over water bath. The product thus obtained was recrystallised from aqueous alcohol.

Yield = 5.6 g.

Melting-point...... = 238—41°d.

The salt is white crystalline (needles) solid. It is extremely soluble in water, less so in methyl and ethyl alcohol and practically insoluble in chloroform, carbon-tetra-chloride, acetone, ethyl acetate, benzene, ether and petroleum ether.

Found : S=12.73%

C_{10} H_{15} $0S0_3$ $H.NH_3$ requires S=12·85%

Ammonium-L-camphor-β-sulphonate.

Using 6 g. of L-camphor the ammonium salt was obtained by a method analogous to that given for ammonium-D-camphor-β-sulphonate.

Yield = 5·8 g.
Melting-point. = 238-41°d
Found : S=12·65%
C_{10} H_{15} $0S0_3$ $H.NH_3$ requires S=12·85%

The rotatory power determinations were made in a 2 d cm. tube. The results are recorded in tables 1-3.

Table 1

Rotatory Power of Ammonium-camphor-β-sulphonate.

Temperature=11.5° C
Solvent =Water.

Line (λ)	Specific Rotation [α]	
	D—Salt Concentration=0·9948 g./100 ml.	L—Salt Concentration=0·9948 g./100 ml.
Hg_{4358}	+73·38°	−73·38°
Li_{4603}	54·78	54·28
Cd_{4678}	50·76	50·26
Cd_{4800}	44·73	45·23
Cd_{5086}	35·18	36·18
Hg_{5461}	27·14	27·14
Hg_{5780}	22·61	22·61
Na_{5893}	21·10	21·10
Li_{6104}	18·59	18·09
Ne_{6402}	16·58	17·08
Cd_{6438}	16·08	16·58
Li_{6708}	14·57	14·57

No Mutarotation

Table 2

Rotatory Power af Ammonium—camphor—β—sulphonate

Temperature = 11.5° C

Solvent = Methyl alcohol

Line (λ)	Specific Rotation $[\alpha]$	
	D—Salt Concentration=0·9996 g/100 ml.	L—Salt Concentration=1·0000 g/100 ml.
Hg_{4358}	+100·54°	−100·50°
Li_{4603}	79·53	79·00
Cd_{4678}	74·52	74·00
Cd_{4800}	67·02	67·50
Cd_{5086}	54·52	54·50
Hg_{5461}	43·51	43·50
Hg_{5780}	36·51	37·00
Na_{5893}	34·51	34·50
Li_{6104}	31·51	31·50
Ne_{6402}	27·51	27·50
Cd_{6438}	27·01	27·00
Li_{6708}	24·50	24·50

Shows mutarotation after 23½ hrs. for D—salt $\left[\alpha\right]^{11\cdot5°}_{54\cdot61} = +41\cdot51°$ and for L—Salt $\left[\alpha\right]^{11\cdot5°}_{54\cdot61} = -41\cdot00°$

Table 3

Rotatory Power of Ammonium—camphor—β—sulphonate

Temperature = 11·5° C

Solvent = Ethyl alcohol

Line (λ)	Specific Rotation [α]	
	D—Salt Concentration = 1·0000 g/1000 ml.	L—Salt Concentration = 0·9992 g/100 ml.
Hg_{4358}	+115·00°	—115·09°
Li_{4603}	91·50	91·07
Cd_{4678}	85·00	85·56
Cd_{4800}	77·00	77·06
Cd_{5086}	62·00	62·04
Hg_{5461}	49·00	49·03
Hg_{5780}	41·00	40·53
Na_{5893}	39·00	38·53
Li_{6104}	35·00	35·02
Ne_{6402}	30·50	30·52
Cd_{6438}	30·00	30·02
Li_{6708}	27·00	26·52

Shows mutarotation after 21½ hrs. for D—salt $\left[\alpha\right]^{11\cdot5°}_{54\cdot61} = +45\cdot54°$ and for L—salt $\left[\alpha\right]^{11\cdot5°}_{54\cdot61} = -45\cdot54°$

The rotatory power given in Tables 1—3 was analysed by the method of Lowry[8]. On plotting $1/[\alpha]$ against λ^2, a straight line was obtained in each case. This indicated that the compound shows simple dispersion and hence the rotations can be expressed by one term of Drude's equation. In each case the equations were calculated. The difference between the calculated values and the observed values is shown in table 4-6.

Table 4

Comparison of the theoretical and observed values of specific rotation in case of ammonium-camphor-β-sulphonate.

Solvent = Water
Temperature = 11·5° C

$$[\alpha] = \pm \frac{4{\cdot}661}{\lambda^2 - 0{\cdot}1263}$$

Line (λ)	(C) Calculated [α]		(O) Observed [α]		Difference (O-C)	
	D—Salt	L—Salt	D—Salt	L—Salt	D—Salt	L—Salt
Hg_{4358}	+73·28°	−73·28°	+73·38°	−73·38°	+0·10	+0·10
Li_{4603}	54·51	54·51	54·78	54·28	+0·27	−0·23
Cd_{4678}	50·40	50·40	50·76	50·26	+0·36	−0·14
Cd_{4800}	44·81	44·81	44·73	45·23	−0·08	+0·42
Cd_{5086}	35·23	35·23	35·18	36·18	−0·05	+0·95
Hg_{5461}	27·13	27·13	27·14	27·14	+0·01	+0·01
Hg_{5780}	22·44	22·44	22·61	22·61	+0·17	+0·17
Na_{5893}	21·10	21·10	21·10	21·10	0·00	0·00
Li_{6104}	18·11	18·11	18·59	18·09	+0·48	−0·02
Ne_{6402}	16·44	16·44	16·58	17·08	+0·14	+0·64
Cd_{6438}	16·17	16·17	16·08	16·58	−0·09	+0·41
Li_{6708}	14·40	14·40	14·57	14·57	+0·17	+0·17

Table 5

Comparison of theoretical and observed values of specific rotation in case of ammonium—camphor —β—sulphonate.

Solvent = Methyl alcohol

Temperature = 11·5° C

$$[\alpha] = \pm \frac{8.280}{\lambda^2 - 0.1078}$$

Line (λ)	(C) Calculated [α]		(O) Observed [α]		Difference (O-C)	
	D—Salt	L—Salt	D—Salt	L—Salt	D—Salt	L—Salt
Hg_{4358}	+100·85°	−100·85°	+100·54°	−100·50°	−0·31	—0·35
Li_{4603}	79·61	79·61	79·53	79·00	—0·08	—0·61
Cd_{4678}	74·59	74·59	74·52	74·00	—0·07	—0·59
Cd_{4800}	67·59	67·59	67·02	67·50	—0·57	—0·09
Cd_{5086}	54·90	54·90	54·52	54·50	—0·38	—0·40
Hg_{5461}	43·51	43·51	43·51	43·50	0·00	—0·01
Hg_{5780}	36·60	36·60	36·51	37·00	—0·09	+0·40
Na_{5893}	34.58	34.58	34·51	34·50	—0·07	—0·08
Li_{6104}	31·28	31·28	31·51	31·50	+0·23	+0·22
Ne_{6402}	27·41	27·41	27·51	27·50	+0·10	+0·09
Cd_{6438}	26·99	26·99	27·01	27·00	+0·02	+0·01
Li_{6708}	24.20	24.20	24·50	24·50	+0·30	+0·30

Table 6

Comparison of theoretical and observed values of specific rotation in case of ammonium—camphor—β—sulphonate.

Solvent= Ethyl alcohol
Temperature= 11.5° C

$$[\alpha] = \pm \frac{9.148}{\lambda^2 - 0.1112}$$

Line (λ)	(C) Calculated [α]		(O) Observed [α]		Difference (O-C)	
	D—Salt	L—Salt	D—Salt	L—Salt	D—Salt	D—Salt
Hg_{4358}	+116·13°	−116·13°	+115·00°	−115·09	−1·13	−1·04
Li_{4603}	90·93	90·93	91·50	91·07	+0·57	+0·14
Cd_{4678}	85·01	85·01	85·00	85·56	−0·01	+0·55
Cd_{4800}	76·80	76·80	77·00	77·06	+0·20	+0·26
Cd_{5086}	62·06	62·06	62·00	62·04	−0·06	−0·02
Hg_{5461}	48·94	48·94	49·00	49·03	+0·06	+0·09
Hg_{5780}	41·05	41·05	41·00	40·53	−0·05	−0·52
Na_{5893}	38·76	38·76	39·00	38·53	+0·24	−0·23
Li_{6104}	35·00	35·00	35·00	35·02	0·00	+0·02
Ne_{6402}	30·63	30·63	30·50	30·52	−0·13	−0·11
Cd_{6438}	30·16	30·16	30·00	30·02	−0·16	−0·14
Li_{6708}	27·00	27·00	27·00	26·52	0·00	−0·48

Discussion

From the tables 4-6 it is clear that there is good agreement between the theoretical and the observed values. The rotatory power of D—and L—forms as given in tables 1—3 lends support to Pasteur's Principle of Molecular Dissymmetry. The difference in 76 readings is seldom beyond the experimental error. These differences do no warrant the questioning of Pasteur's Principle.

In case of non-aqueous solvents there is slight mutarotation after about 24 hours. This observed change in rotation is probably due to the formation of ketimine as suggested by Schreiber and Shriner[5].

CONCLUSION

The ammonium salts of D— and L—camphor—β—sulphonic acid have been prepared and characterised. Their rotatory power in water, methyl alcohol and ethyl alcohol has been studied and it has been found that they exhibit simple dispersion. The salts do not show any appreciable mutarotation in non-aqueous solvents.

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CONDENSATION OF SOME ALIPHATIC, AROMATIC AND HETEROCYCLIC ALDEHYDES WITH CHLORACETAMIDE

By Abraham Thomas and T. George,
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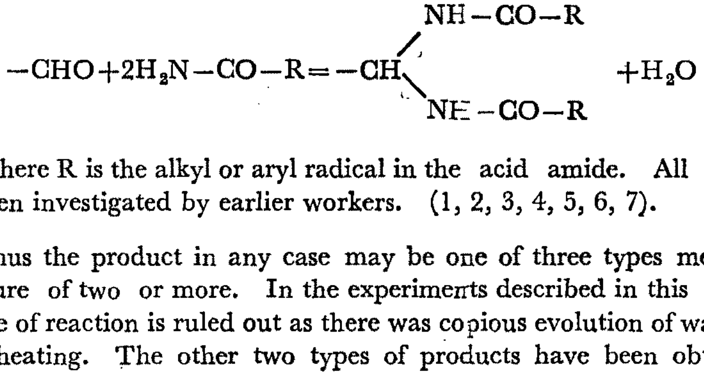
A large number of workers have studied the condensation of aldehydes with acid amides. The effect of pyridine as a catalyst in aldehyde amide condensation has been studied in this laboratory (8). Pyridine was ineffective in some cases, only slightly useful in some others and postively harmful in certain other cases. In quite a number of cases better yields have been obtained, when no condensing agent was used (4).

In the condensation of chloracetamide with *o*-*m*-and *p*-nitrobenzaldehydes, *m*-and *p*-tolualdehydes, piperonal, 6-nitropiperonal, salicylaldehyde, furfuraldehyde, thiophen aldehyde, chloralhydrate, bromal and n-heptaldehyde which forms the subject of this paper, the use of pyridine as a catalyst was avoided since it was found ineffective in the condensation with benzaldehyde. The object of this work has been to study the course which these reactions take.

Regarding the course of the reaction Titherly and Marples (9) suggest three different possibilities.

(a) $-CHO+H_2N-CO-R= \; -CH\,(OH)-NH-CO-R$

(b) $-CHO+H_2N-CO-R= \; -CH{=}N-CO-R+H_2O$

(c) 

$$-CHO+2H_2N-CO-R=-CH\begin{array}{l}\diagup NH-CO-R\\ \diagdown NH-CO-R\end{array}+H_2O$$

Where R is the alkyl or aryl radical in the acid amide. All these types have been investigated by earlier workers. (1, 2, 3, 4, 5, 6, 7).

Thus the product in any case may be one of three types mentioned or a mixture of two or more. In the experiments described in this paper, the first type of reaction is ruled out as there was copious evolution of water vapour during heating. The other two types of products have been obtained. In the case of *o*-nitrobenzaldehyde, *m*-nitrobenzaldehyde, *p*-nitrobenzaldehyde, *m* tolualdehyde, *p* tolualdehyde, thiophenaldehyde and piperonal bis products were obtained as represented in (c) even when the molecular proportions of the aldehyde and amide were 1:1 though the yield was larger when the aldehyde amide ratio was 1:2. In the case of chloral and bromal only mono products could be isolated as in (b). Condensations with 6-nitropiperonal, 2:4- dinitrobenzaldehyde, furfural, salicylaldehyde and n-heptaldehyde were found unsuccessful.

Experimental

Chloracetamide was prepared according to the method described in Org. Synth. Vol. VII, by W. A. Jacobs and M. Heidelberger.

Condensation of chloracetamide wich aldehydes.

The general procedure has been to take the aldehyde and amide in both 1 :1 and 1 :2 molecular proportions and then heat the mixture at 100° - 105° C for four hours. After heating, the products were allowed to cool and extracted with ether. This treatment removed all unreacted aldehyde. Then the residue was repeatedly washed with hot alcohol, chloroform and hot water which removed all the unreacted amide leaving the pure product. The products obtained were recrystallized from suitable solvents analysed and their identity established.

The accompanying table gives the experimental conditions observed and the nature of the products obtained.

Table

Name of product	Yield %	Mol. Formula	M.P. °C	Nitrogen %	
				Calculated.	Found.
1. *o*-Nitrobenzylinene-X	11·7	$C_{11}H_{11}O_4N_3Cl_2$	197	13·13	13·31
2. *m*-Nitrobenzylidene-X	20·5	$C_{11}H_{11}O_4N_3Cl_2$	207	13·13	13·03
3. *p*-Nitrobenzylidene-X	50·0	$C_{11}H_{11}O_4N_3Cl_2$	230	13·13	13·53
4. *m*-Methylbenzylidene-X	8·2	$C_{12}H_{14}O_2N_2Cl_2$	191	9·76	9·70
5. *p*-Methylbenzylidene-X	5·4	$C_{12}H_{14}O_2N_2Cl_2$	210	9·76	9·60
6. 3:4-Methylenedioxybenzylidene-X	10·9	$C_{12}H_{12}O_4N_2Cl_2$	204	8·78	8·83
7. Thiophenylidene-X	10·10	$C_9H_{10}O_2N_2Cl_2$	209	13·4	13·2
8. Trichloroethylidene-X	39·1	$C_4H_3Cl_4ON$	135	6·3	6·83
9. Tribromoethylidene-Y	14·1	$C_4H_3OBr_3ClN$	136	3·93	3·92

Where X stands for bis-chloroacetamide and Y stands for monochloracetamide.

N. B. Time of heating in all cases was four hours and the temperature was maintained between 100 and 105° C. For compounds 1. 2. 3. 6. 7. and 8 yields reported above were obtained when the molar ratio of amide : aldehyde was 1 :1 and in the case of compounds 4 and 5 when the molar ratio was 2 :1.

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CONDENSATION OF MALON-*O*-,*M*-AND *P*-CHLORANILIC ACIDS WITH ALDEHYDES—Part V.* WITH VANILLIN AND PIPERONAL

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The condensation of malonic acid with protocatechuic aldehyde, vanillin, veratraldehyde and piperonal in the presence of organic bases like pyridine and piperidine have been reported by Pandya and Vahidy [7,8,9.] and Pandya and Sodhi [5,6]. The condensation of these aldehydes with malonanilic acid has been studied by Ittyerah and Pandya [2]. The same authors have later condensed malon-*o*-, *m*-and *p*-toluidic acids with vanillin veratraldehyde and piperonal [4].

Earlier experiments have shown that the presence of a hydroxyl group in the aldehyde molecule exerts an inhibitive effect on the activity of the aldehyde group. This is most noticeable when the hydroxy group is in the ortho position, to the aldehyde group. In the case of polyhydroxy aldehydes this effect is more pronounced. Thus when protocatechuic aldehyde was condensed with malonanilic acid nothing but a resinous mass was obtained. This could not be further purified and no definite product could be isolated [2]. But when the hydroxy groups were replaced by methoxy groups a steady improvement in the yields of the products was observed. Thus the yields of the products obtained from the condensation of the monomethoxy-benzaldehydes were superior to those from the monohydroxy-benzaldehydes [1,3,8,9]. Also vanillin, veratraldehyde and piperonal condensations gave better yields of the products than those obtained from protocatechuic aldehyde. [2,7].

The present paper deals with the condensation of malon-*o*-, *m*-and *p*-chloranilic acids with vanillin and piperonal. The condensations have been carried out under various conditions. Various condensing agents like glacial acetic acid, pyridine, piperidine, 2:4—lutidine, collidine, triethanolamine, pyridine acetate and piperidine acetate were used. All except glacial acetic acid were used in traces, *i. e.*, 0·15 mol. of the catalyst for every mol. of the aldehyde taken. The presence of a trace of an organic base catalysed the reaction and the product obtained was mainly the corresponding cinnamchloranilide. In the absence of any condensing agent or when glacial acetic acid was used the product was mainly the corresponding benzylidene-malonchloranilic acid. Of all the condensing agents used piperidine, and piperidine acetate were found to be most effective. From the condensation of malon-*m*-chloranilic acid and vanillin only the acid product could be isolated.

All the products obtained were white crystalline solids and the acid products melted with decomposition. They were all analysed and their properties studied. They are shown in Table I.

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*This journal, 1959, 8, Part II, 281.

Tables II and III show the maximum yields of products and the conditions under which they were obtained.

As expected piperonal was found to be much more reactive than vanillin.

EXPERIMENTAL

In all cases the aldehyde and the acid were taken in equimolecular quantities, mixed well and heated at 100°C for four to five hours. Acetic acid when used as the condensing agent was added to the above mixture in equimolecular proportion, while the organic bases were added in traces [0·15 mol.]. After heating for the required length of time the contents of the flask were treated with a saturated solution of sodium bicarbonate. The non-acid residue left was filtered off and further purified by repeated recrystallisation from alcohol or acetone. The alkali extract on acidification with hydrochloric acid yielded the acid product generally in white crystalline form.

TABLE I

No.	Name	Mol. Form.	M.p.°C	Chlorine%		Nitrogen%	
				Found	Calc.	Found	Calc.
1.	3-Methoxy-4-hydroxybenzylidene-malon-*o*-X	$C_{17}H_{14}O_5NCl$	180			4.07	4.02
2.	3-Methoxy-4-hydroxycinnam-*o*-Y	$C_{16}H_{14}O_3NCl$	170			4·63	4·61
3.	3-Methoxy-4-hydroxybenzylidene-malon-*m*-X	$C_{17}H_{14}O_5NCl$	175	10.35	10.2		
4.	3-Methoxy-4-hydroxybenzylidene-malon-*p*-X	$C_{17}H_{14}O_5NCl$	202	9.96	10.2		
5.	3-Methoxy-4-hydroxycinnam-*p*-Y	$C_{16}H_{14}O_3NCl$	191			4.65	4.61
6.	3 : 4 Methylene dioxy benzylidene malon-*o*-X	$C_{17}H_{12}O_5NCl$	206			1.01	1.05
7.	3 : 4-Methylene-dioxy-cinnam-*o*-Y	$C_{16}H_{12}O_3NCl$	165			4.62	4.64
8.	3 : 4-Methylene-dioxy-benzylidene-malon-*m*-X	$C_{17}H_{12}O_5NCl$	215	10.49	10.26		
9.	3 : 4-Methylene-dioxy-cinnam-*m*-Y	$C_{16}H_{12}O_3NCl$	145	11.95	11.75		
10.	3 : 4-Methylene-dioxy-benzylidene-malon-*p*-X	$C_{17}H_{12}O_5NCl$	217	10.17	10.26		
11.	3 : 4-Methylene-dioxy-cinnam-*p*-Y	$C_{16}H_{12}O_3NCl$	193	12.00	11.75		

X stands for chloranilic acid and Y stands for chloranilide.

TABLE II
With vanillin

No.	Acid	Condensing agent	Mol. prop.	Time [Hrs]	Temp. [°C]	Yield%	
						Acid	Chloranilide
1.	Malon-*o*-chloranilic acid	Gl. Acetic acid	1:1:1	4	100	40	0
2.	,, ,,	Piperidine acetate	1:1:0.15	4	,,	0	88
3.	Malon-*m*-chloranilic acid	Gl. Acetic acid	1:1:1	4	,,	68	0
4.	Malon-*p*-chloranilic acid	Gl. Acetic acid	1:1:1	4	,,	71	0
5.	,, ,,	Pyridine acetate	1:1:0.15	5	,,	0	88

TABLE III
With piperonal

No.	Acid	Condensing agent	Mol. prop.	Time [Hrs.]	Temp. [°C]	Yield%	
						Acid	Chloranilide
1.	Malon-*o*-chloranilic acid	Gl. acetie acid	1:1:1	4	100	71	0
2.	,, ,,	Piperidine acetate	1:1:0.15	4	,,	0	85
3.	Malon-*m*-chloranilic acid	Gl. acetic acid	1:1:1	4	,,	62	0
4.	,, ,,	Piperidine acetate	1:1:0.15	4	,,	0	85
5.	Malon-*p*-chloranilic acid	Gl. acetic acid	1:1:1	4	,,	74	0
6.	,, ,,	Pyridine acetate	1:1:0.15	6	,,	0	92

SUMMARY

Malon-*o*-,*m*-and *p*-chloranilic acids were condensed with vanillin and piperonal under various conditions. The effect of various condensing agents like glacial acetic acid, pyridine, piperidine, lutidine, triethanolamine, collidine, pyridine acetate and piperidine acetate on these condensations was studied. It was observed that piperidine acetate in traces was the best among the condensing agents tried. When glacial acetic acid was used or when the reactions were carried out in the absence of condensing agents the products were mainly the corresponding benzylidene-malonchloranilic acids. When organic bases or their salts were used the products were wholly the corresponding cinnamchloranilids. Piperonal was found to be more reactive than vanillin.

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CONTRIBUTION OF VALENCE BONDS OF A GASEOUS MOLECULE TO γ—THE RATIO OF ITS TWO SPECIFIC HEATS

By WAZIR CHAND VASUDEVA, *Department of Chemistry, Agra College, Agra* and RAM SWARUP SINGH, *Department of Physics, Agra College, Agra.*

The molecular heat at constant volume C_v of a monatomic gas is $\frac{3}{2}$ R per degree rise of temperature, or $3g$. cal. since R is nearly equal to 2. The molecular heat at constant pressure C_p is

$$\frac{3}{2}\,R+R \text{ or } \frac{5}{2}\,R \text{ or } 5g.\text{ cal.}$$

$$\text{Hence } \gamma=\frac{C_p}{C_v}=\frac{5}{3}=1{\cdot}66.$$

The heat absorbed increases the kinetic energy of translation of the molecule which could be expressed with reference to three axis at right angles to one another. The molecule has three degrees of freedom ($f=3$) and according to the principle of equipartition of energy (Maxwell and Boltzmann) the energy (in C_v) per degree of freedom is $\frac{1}{3}\times 3g$. cal $=1g$. cal.

In the case of a diatomic molecule in which the two atoms are rigidly kept apart by a definite bond length, there are, in addition to the three degrees of translational freedom, two degrees of rotational freedom in planes perpendicular to one another. The rotation of the molecule along its own axis need not be taken into account as this is not affected by collision of the molecule. Such a molecule has thus five degrees of freedom ($f=5$), and since the energy per degree of freedom is $1g$. cal its $C_v=1\times 5g$. cal$=5g$. cal. Its C_p is $5+2=7g$. cal. Hence in this case

$$\gamma=\frac{7}{5}=1{\cdot}40$$

In a polyatomic molecule rotation along the axis of the molecule is affected by its collision. It has, therefore, three degrees of rotational freedom and in all six degrees of freedom ($f=6$) and its $C_v=6g$. cal. In this case

$$\gamma=\frac{6+2}{6}=\frac{8}{6}=1{\cdot}33.$$

The observed values for C_v of some di and poly-atomic molecules are not, however, in agreement with those deduced theoretically as above, as will be seen from the following table :

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Table I

Observed values of C_V of some di-and poly-atomic molecules.

Diatomic		Triatomic		Polyatomic	
H_2	4·87	H_2O	6·00	NH_3	7·05
N_2	4·99	CO_2	7·70		
O_2	4·99	SO_2	8·1		
Cl_2	6·30				
Hcl	5·00				

Thus whereas diatomic hydrogen is lower than 5, the theoritical value, diatomic chlorine is much higher than 5. Again triatomic water is 6, but triatomic CO_2 and SO_2 are much higher, the latter being abnormally high. Further tetratomic ammonia is lower than triatomic CO_2 and SO_2.

These discrepancies are explained by assuming that in certain molecules the atoms absorb additional energy due to their vibration along molecular axis. Such an assumption will not however explain cases where the observed value of C_V is lower than the theoretical.

One of the causes of this discrepancy between the observed and theoretical values of C_V is the fact that we are not taking into account the part played by the valence bonds of the molecule in energy absorption. It will not be correct to suppose that there would be equal amount of energy absorption by diatomic hydrogen and diatomic oxygen molecules. In the former the atoms are connected by a single bond, in the latter by a double bond which has a plane whose rotation about the molecular axis will be affected by collision. It should have, therefore, three degrees of rotational freedom and its energy absorption should, therefore, be greater than that of hydrogen. This effect of a double bond is conspicuously seen in the molecules $C0_2$ and $S0_2$ which contain two double bonds each. The values of C_V in their cases are much above 6, the theoretical value.

A rational line of approach to this problem is to imagine that the total energy absorbed is on account of (a) the constituent atoms of the molecule and (b) the valence bonds of the molecule. If M and E respectively represent the amounts absorbed

$$C_V = M + E$$

When E=O we are having a bond-less molecule, as for instance a monatomic molecule. In this case C_V has the minimum and γ the maximum value.

With the introduction of a bond C_V is raised and γ lowered. We may, therefore, say that the contribution of a valence bond to γ, is on the negative side. In the case of a hydrogen molecule for instance if S represents the contribution of one single bond and γ^0_{H2}, that of the atomic constituent of the molecule (the bondless constituent) then

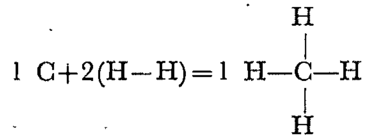
$$\gamma^0_{H2} - S = \gamma_{H2} \text{ (the observed value)}$$

$$\text{or } \gamma^0_{H2} \text{ (contribution of bondless molecule)} = \gamma_{H2} + S.$$

If a C—H single bond is assumed to have the same contribution as an H—H single bond then for the molecule of methane we should have

$\gamma^0_{CH_4} = \gamma_{CH_4} + 4S$ ($\because CH_4$ has four single bonds). Where γ^0 and γ stand for the values of bondless and bonded entities respectively.

In a chemical reaction by addition of two or more entities (atoms or molecules), if we eliminate the effect of the bonds in the entities, then the bond-less constituents of the entities merely remain as a mixture. The value γ^0 of the bond-less mixture could in such a case be obtained by applying the mixture law. For instance if methane be regarded as formed by addition (chemically) of one atom of carbon to two molecules of hydrogen :



$$1\ C + 2(H-H) = 1\ H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-H$$

and if γ^0_c and γ^0_{H2} are, by usual notations, the values of the two bondless entities respectively, the value of γ_0 of the bondless mixture will be :

$$\frac{1}{3}\ \gamma^0_c + \frac{2}{3}\gamma^0_{H2} \text{ or } \frac{1}{3}\ \gamma^0_c + \frac{2}{3}(\gamma_{H2}+S)$$

$$\text{Also } \gamma^0_{CH4} = \gamma_{CH4} + 4S$$

$$\therefore \frac{1}{3}\ \gamma^0_c + \frac{2}{3}(\gamma_{H2}+S) = \gamma_{CH4} + 4S$$

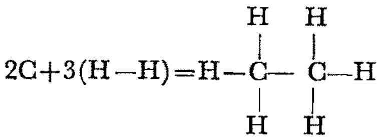
$$\text{On simplifying } \gamma^0_c - 10\ S = 3\ \gamma_{CH_4} - 2\ \gamma_{H2}$$

In this equation the two unknown terms are γ^0_c and S. The values of γ_{CH4} and γ_{H2} are known. They are (the observed values) 1·31 and 1·41 respectively.

$$\text{Hence } \gamma^0_c - 10\ S = 3 \times 1{\cdot}31 - 2 \times 1{\cdot}41 = 1{\cdot}11 \qquad \text{......(1)}$$

In order to arrive at the values of the two unknown terms we should have another equation with these very unknown terms.

For this purpose we consider the reaction



$$2C + 3(H-H) = H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-H$$

With the usual notation

$$\frac{2}{5}\ \gamma^0_c + \frac{3}{5}\ (\gamma_{H2}+S) = \gamma_{C_2H_6} + 7S$$

On simplifying

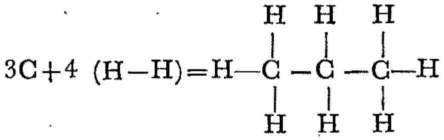
$$2\gamma^0{}_c - 32S = 5\gamma_{c_2H_6} - 3\gamma_{H_2}$$
$$= 5 \times 1{\cdot}22 \text{ (value of } \gamma_{c_2H_6}) - 3 \times 1{\cdot}41$$
$$= 1{\cdot}87 \qquad \ldots\ldots(2)$$

From equations (1) and (2) we get

$$\gamma^0{}_c = 1{\cdot}42 \text{ and } S = {\cdot}03 \text{ (app.)}$$

These values of $\gamma^0{}_c$ and 'S' could be used in calculating the value of $\gamma_{c_3H_8}$.

In this case we have



$$3C + 4\ (H-H) = H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-H$$

$$\text{Hence} \quad \frac{3}{7}\gamma^0{}_c + \frac{4}{7}(\gamma_{H_2}+S) = \gamma_{c_3H_8} + 10S$$

The solution of this equation gives $\gamma_{c_3H_8} = 1{\cdot}132$

The observed value is 1·130.

The contribution of a double bond could be found from the equation

$$C + O{=}O \;=\; O{=}C{=}O$$

If the double bonds O=O and C=O have equal contribution and it is expressed by D then

$$\tfrac{1}{2}\gamma^0{}_c + \tfrac{1}{2}(\gamma^0{}_{O_2} + D) = \gamma_{CO_2} + 2D$$

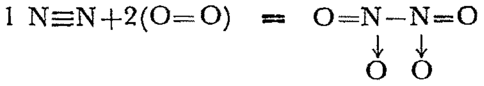
D can be found from this equation since $\gamma^0{}_c = 1{\cdot}42$ and the observed values of $\gamma^0{}_{O_2}$ and γ_{CO_2} are known to be 1·400 and 1·300 respectively. D is thus found to be equal to 0·0715.

Similarly the contribution of a triple bond, expressed by T can be found from the equation

$$2C + H-H \;=\; H-C{\equiv}C-H$$

T is found to be equal to 0·1046

For determining the value of a co-ordinate bond expressed by 'C' we may take the formation of N_2O_4.



$$\text{Here} \qquad 1\ N{\equiv}N + 2(O{=}O) \;=\; O{=}\underset{\underset{O}{\downarrow}}{N}-\underset{\underset{O}{\downarrow}}{N}{=}O$$

If the triple bond N≡N has the same contribution as the triple bond C≡C then we have

$$\frac{1}{3}(\gamma_{N_2} + T) + \frac{2}{3}(\gamma^0{}_{O_2} + D) = \gamma_{N_2O_4} + S + 2D + 2C$$

$$\text{Now} \quad \gamma_{N_2} = 1{\cdot}410 \qquad S = 0{\cdot}0297$$
$$\gamma_{O_2} = 1{\cdot}400 \qquad D = 0{\cdot}0715$$
$$\gamma_{N_2O_4} = 1{\cdot}172 \qquad T = 0{\cdot}1046$$

Putting these values in the above equation 'C' comes out to be 0·0703.

The values of the contributions of valency bonds thus deduced could be used to find the values of γ^0 of elements. For instance γ^0 for sulphur could be obtained from the equation

$$1S+1(H-H)=H-S-H$$

$$\therefore\ \tfrac{1}{2}\gamma^0_S+\tfrac{1}{2}\ (\gamma_{H_2}+S)=\gamma_{H_2S}+2S$$

Substituting the value of 'S' and of γ_{H_2} and γ_{H_2S} (observed) the value of γ^0_S is found to be 1·362.

A test of the correctness of this line of approach to the problem is to see whether the calculated values of γ in the case of a few compounds are in agreement with the observed values. Two simple cases are chosen for the purpose.

(1) To find the value of γ_{N_2O}

We have

$$1\ N\equiv N+\tfrac{1}{2}\ (0=0)=N\equiv N\rightarrow 0$$

$$\therefore\ \frac{2}{3}\ (\gamma_{N_2}+T)+\frac{1}{3}(\gamma_{O_2}+D)=\gamma_{N_2O}+T+C$$

Substituting the values of D, T, and C and also of γ_{N_2O} and γ_{O_2} (observed), γ_{N_2O} is found to be 1.326. The observed value of γ_{N_2O} is 1·324.

(2) To find the value of γ_{CS_2}

We have

$$1C+\ 2S=S=C=S$$

$$\therefore\ \frac{1}{3}\ \gamma^0_C+\frac{2}{3}\ \gamma^0_S=\gamma_{CS_2}+2D.$$

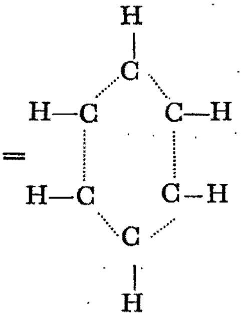
Substituting the values of γ^0_C, γ^0_S and D (all deduced theoretically) γ_{CS_2} is found to be 1·236. The observed value of γ_{CS_2} is 1·239.

Although the values of γ for atoms and molecules vary within a narrow range of 1·1 and 1·6, these values are quite sharp. They are accurately observed and also accurately calculated. If the above cases showing closeness of the observed and calculated values constitute sufficient proof of the correctness of this mode of approach to the constitution of a molecule, its utility in dealing with structural problems will be obvious.

We may apply it to the structural problem of benzene. In this molecule there are six C−H single bonds and six C......C bonds of equal value. The latter are neither single nor double bonds. They are the characteristic bonds of an aromatic nucleus. Let them be designated by 'B'.

We have

$6C+3(H-H)=$



$$\therefore\ \frac{6}{9}\,\gamma^{0}{}_{c} + \frac{3}{9}(\gamma_{H_2}+S)=\gamma_{C_6H_6}+6S+6B$$

Substituting the values of $\gamma^{0}{}_{c}$ and 'S' (calculated) and of γ_{H_2} and $\gamma_{C_6H_6}$ (observed), 'B' is found to be $-0{\cdot}026$.

This result is strikingly in agreement with the fact that the stability of a bond increases in the ascending order

$$\equiv < = < -$$

and in the descending order of the magnitude of its contribution to γ

$$0{\cdot}1046 > 0{\cdot}0715 > 0{\cdot}03.$$

The magnitude of the contribution of the aromatic bond namely $-0{\cdot}026$, is the lowest and it is also the stablest.

ACKNOWLEDGEMENT

We wish to express our grateful thanks to Dr. S. S. Deshpande, M. Sc., Ph. D. (London), F. R. I. C. (London), Indore for his kind suggestions and useful discussions.

SOME NEW SELF RECIPROCAL FUNCTIONS

By GOPAL KRISHNA, M. Sc., *K. N. Government College, Gyanpur, Varanasi.*

1. Hardy and Titchmarsh* have proved that a necessary and sufficient condition that a function $f(x)$ of A (ω, a) should be its own Hankel transform of order μ is that it should be of the form.

$$f(x)=\frac{1}{2\pi i}\int_{c-\infty i}^{c+\infty i} 2^{\frac{1}{2}s}\,\Gamma\left(\tfrac{1}{4}+\tfrac{1}{2}\mu+\tfrac{1}{2}s\right)\psi(s)\,x^{-s}ds \qquad (1.1)$$

where $\psi(s)$ is regular and satisfies the condition

$$\psi(s)=\psi(1-s) \qquad (1.2)$$

in the strip $a<\sigma<1-a$

and $$\psi(s)=O\left\{e^{(\frac{1}{4}\pi-\omega+\eta\,|t|}\right\}, \text{ (where } s=c+it) \qquad (1.3)$$

for every positive η and uniformly in any strip interior to (1.3) and where c is any value of σ in (1.3).

Function $f(x)$ of A (ω, a) where $0<\omega\leq\pi$ and $a<\frac{1}{2}$ implies that $f(x)$ is (i) an analytic function of $x=re^{i\theta}$ regular in the angle A defined by $r>0$, $|\theta|<\omega$ and (ii) it is $O\left\{|x|^{-a-\delta}\right\}$ for small x and $O\left[|x|^{a-1+\delta}\right]$ for large x for every positive δ and in any angle $|\theta|\leqslant\omega-\eta<\omega$.

The object† of this paper is to prove that functions of the type $\int_0^\infty I_\nu(xy)\,K_\nu(xy)\,f(y)\,dy$ and $\int_0^\infty I_\nu(y)\,K_\nu(y)\,f(xy)\,dy$ for $\nu=\frac{1}{2}\mu-\frac{1}{4}$ are also self-reciprocal functions.

2. From a formula given by Erdelyi‡, after a suitable substitution, we get

$$I=\int_0^\infty y^{-s}\,I_\nu(xy)\,K_\nu(xy)\,dy$$

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* Hardy and Titchmarsh—Self reciprocal functions, Quarterly Journal of Mathematics, Oxford Series I (3) 1930.

† I take this opportunity to thank Dr. J. L. Sharma for his constant help and guidance in writing this paper.

‡ Erdelyi,—"Tables of Integral Transform" Vol. I p. 333 formula (43).

$$=\frac{\Gamma\left(\frac{s}{2}\right)\Gamma\left(\frac{1-s}{2}\right)}{2\sqrt{\pi}}\int_0^\infty z^{-s}\,J_{2\nu}\,(2\,z\,x)\,dz$$

$$=\frac{\Gamma\left(\frac{s}{2}\right)\Gamma\left(\frac{1-s}{2}\right)\Gamma\left(\frac{1}{2}+\nu-\frac{s}{2}\right)}{4\sqrt{\pi}\;\Gamma\left(\frac{1}{2}+\nu+\frac{s}{2}\right)}\,x^{s-1} \qquad (2{\cdot}1)$$

3. **Theorem I.** If $f(x)$ is R_μ and

$$G(x)=\int_0^\infty I_\nu(xy)\,K_\nu(xy)\,f(y)\,dy \qquad (3.1)$$

where $\nu=\frac{1}{2}\mu-\frac{1}{4}$, then $G\left(\frac{x}{2}\right)$ is self reciprocal function of order $(\mu-1)$.

From (1.1)

$$G(x)=\int_0^\infty I_\nu(xy)\,K_\nu(xy)\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty}2^{\frac{1}{2}s}\,\Gamma\left(\tfrac{1}{4}+\tfrac{1}{2}\mu+\tfrac{1}{2}s\right)\psi(s)\,y^{-s}\,ds\,dy$$

$$=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty}\int_0^\infty y^{-s}\,I_\nu(xy)\,K_\nu(xy)\,2^{\frac{1}{2}s}\,\Gamma\left(\tfrac{1}{4}+\tfrac{1}{2}\mu+\tfrac{1}{2}s\right)\psi(s)\,dy\,ds$$

$$(3.2)$$

The inversion of the order of integration is justified as shown in the next article. Therefore from (2.1)

$$G(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty}\tfrac{1}{4}\sqrt{\pi}\;\Gamma\left(\frac{s}{2}\right)\Gamma\left(\frac{1-s}{2}\right)\frac{\Gamma\left(\frac{1}{2}+\nu-\frac{s}{2}\right)}{\Gamma\left(\frac{1}{2}+\nu+\frac{s}{2}\right)}\,2^{\frac{1}{2}s}x^{s-1}\;\Gamma\left(\tfrac{1}{4}+\tfrac{1}{2}\mu+\tfrac{1}{2}s\right)\psi(s)\,ds.$$

Therefore putting $\nu=\frac{1}{2}\mu-\frac{1}{4}$ and replacing s by $1-s$, we get

$$G(x)=\frac{1}{2\pi i}\int_{1-c-\infty i}^{1-c+\infty i}\Gamma\left(\frac{1}{4}+\frac{\mu-1}{2}+\frac{s}{2}\right)(2x)^{-s}\,2^{\frac{1}{2}s}\,X(s)\,ds \qquad (3.3)$$

where $X(s)=2^{\frac{1}{2}}\dfrac{1}{4\sqrt{\pi}}\Gamma\left(\dfrac{s}{2}\right)\Gamma\left(\dfrac{1-s}{2}\right)\psi(s)$

Comparing (1.1) and (3.3) we find that $G\left(\frac{x}{2}\right)$ is $R_{\mu-1}$ i. e. $G\left(\frac{x}{2}\right)$ is its own Hankel Transform of order $(\mu-1)$.

4. To justify the inversion of the order of intergration in (3.2) consider the integral

$$= \int_0^\infty \left| I_\nu (xy) K_\nu (xy) \right| dy \int_{-\infty}^{+\infty} 2^{\frac{1}{2}c} \left| \left(m + \frac{it}{2} \right) \right| \left| \psi(s) \right| y^{-c} \, dt \tag{4.1}$$

where $m = \frac{1}{2}c + \frac{1}{2}\mu + \frac{1}{4}$ and $s = c + it$.

We know that as

$$|t| \longrightarrow \infty \quad \left| \overline{m + \frac{it}{2}} \right| \sim C \, e^{-\frac{1}{4}\pi |t|} \left| \tfrac{1}{2} t \right|^{m-\frac{1}{2}}$$

Therefore I is not greater than a constant multiple of

$$X^{c-1} \int_0^\infty | u^{-c} I_\nu (u) K_\nu | (u) \, du \int_{-\infty}^{+\infty} |t|^{m-\frac{1}{2}} e^{-\frac{1}{4}\pi |t|} \left| \psi(s) \right| dt \tag{4.2}$$

Hence the inversion is justified if two integrals in (4.2) exist. The t—integral will exist* as $f(x)$ belongs to A (ω, a). From (2.1) we see that the u—integral also exists.

Therefore I is uniformly convergent throughout any domain of $x = re^{i\theta}$ where $r > 0$, $0 < \theta < \omega < \pi$.

5. **Theorm II.** If $f(x)$ is R_μ and

$$G(x) = \int_0^\infty I_\nu (y) K_\nu (y) f(xy) \, dy \tag{5.1}$$

where $\nu = \frac{1}{2}\mu - \frac{1}{4}$, then $\frac{2}{x} G\left(\frac{2}{x}\right)$ is $R_{\mu - 1}$.

This can easily be proved from Theorem I after a suitable substitution.

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* Hardy and Titchmarsh, loc. cit. Theorem 4.

SOME ASPECTS OF THE BIONOMICS OF *EARIAS* SPP. AT KANPUR

By C. P. PANT,[1] M. Sc., Ph. D., *Government Agriculture College, Kanpur.*

Cotton is attacked by several insects in different parts of the world. The spotted bollworms, *Earias insulana* Boisd, and *Earias fabia* Stoll have special significance on account of their great capacity to do extensive damage to all the stages of cotton plants. Froggatt (1922) reported a world wide distribution of the genus *Earias*. Hampson (1892) has described 21 species of this genus from different parts of the world. Wardle (1929) reported the absence of this genus from the Americas. In India the spotted bollworms have been reported from nearly all the cotton growing parts (Deshpande and Nadkarny, 1936; Fletcher and Misra, 1919; Haroon Khan, 1941; Hector, 1924; Husain, 1931; Jhaveri, 1921; Lal, 1917; Richards, 1924; and Sharga, 1940). The spotted bollworms are stated to have caused the failure of cotton crop in Punjab (India and Pakistan) and Sind in 1905, 1906 and again in 1928-29 (Lefroy 1906; and Husain, 1928-29).

MATERIALS AND METHODS

The life history was studied by rearing the spotted bollworms in glass chimneys in the laboratory. The adults were fed on dilute sugar solution soaked in a cotton wick. The larvae were fed on fresh buds and young bolls of cotton. In the field, mass rearing was done in large wiregauge cages of approximately one and a half feet in diameter and three feet in height.

The local malvaceous plants occurring as weeds in the areas adjoining the cotton fields and those grown separately for ornamental or agricultural purposes were examined thorougly for larvae of spotted bollworms.

The predator which was collected in the field was reared in the laboratory. Fresh larvae were supplied to the nymphs and adults of the predator.

The parasites were reared in the laboratory from parasitized larvae and pupae collected from the field. The adult parasites were kept in glass tubes of about 2″ in diameter and 3″ in height. The adult parasites were supplied with larvae of *Earias* spp. for oviposition and dilute sugar syrup for feeding.

LIFE HISTORY

The adult moths copulated on the third night after emergence. It was observed that themales and females of approximately the same age copulated. Copulation occurred freely in captivity. During the early hours of morning

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This piece of work was carried out under the guidance of Dr. U. S. Sharga, Professor of Entomology, Agriculture College, Kanpur to whom the author whishes grateful thanks.

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from 5 A.M. to 8 A.M., a large number of moths were collected *in copula* from the fields of cotton and bhindi, *Hibiscus esculentus.*

The preoviposition period was from 2 to 4 days. Eggs were laid singly on the leaves, buds, shoots, calyx and petioles in between the hair occurring in these plants (*Malvaceae* family). In the field more eggs were found on the lower surfaces of the leaves than any other part. Deshpande and Nadkarny (1936) observed that the females preferred hairy parts of the plants to non-hairy parts for egg laying. Eggs were laid only at night. The above authors have also recorded that eggs were laid only at night and that artificial darkness did not induce egg laying. Ahmed and Ghulamullah (1941) have, however, shown that the spotted bollworm females also laid eggs during day time.

Eggs were small, oval and bluish green in colour when freshly laid, with parallel longitudinal ridges which extended towards the upper end to form a circlet known as crown. Four females laid 92, 245, 275 and 323 eggs respectively during oviposition periods of 7, 3, 4, and 5 days respectively. The colour of eggs during development changed from bluish green to lighter green and slowly to brownish and to pinkish. At this stage the mandibles of the first instar larva could be seen. During the months of July, August and September the eggs hatched after 3-4 days. During the months of January and February it took 8-9 days. In south Gujrat Deshpande and Nadkarny (1936) have shown that the incubation period was 4 days throughout the year except during December and January when it was 5-7 days.

After complete development, tiny larvae hatched out. Slight movements of the larva were observed inside the shell prior to hatching. It made an irregular hole on one side of the egg shell which became whitish in colour after the eclosion of the larva.

The larvae of spotted bollworms were marked with brown, greenish white and orange spots. The larvae of *Earias fabia* appeared to be soft and glossy. When fully grown the larvae measured 3/4" in length. The dorsum of *Earias fabia* larvae was brownish with a white median longitudinal streak which was widest in the thoracic region. Larvae of *Earias insulana* could be distinguished from *Earias fabia* when fully grown. The prothorax had a pair of transverse stripes. Mesothorax was dull olive coloured with two pairs of finger shaped processes, the median pair longer than the lateral. The metathorax also possessed similar processes. White patches were more extensive in the first abdominal segment and two pairs of processes equal in size were present in this segment. The general appearance of the larvae was greenish white. The larvae of *Earias cupreoviridis* Wlk. were similar in appearance to *Earias insulana,* the only difference being that the general colour was more brownish with slight orange tinge.

HABITS OF THE LARVAE

The larvae were migratory in habit. The young larvae fed on soft growing parts of the plants and with growth in size the larvae moved from one bud, boll or flower to another. During the months of July and August when the cotton crop had grown to about one foot or more in height, the larvae bored the terminal shoots inhibiting the growth of the top shoot (fig. 1). It was observed that almost 10% of the young plants were destroyed in this way. Later the larvae started feeding on the buds. With the appearance of buds and bolls during the later part of the season, the larvae started feeding on these parts. Thus developing lint and seeds were destroyed. The damaged bolls had one or two holes and brownish excreta of the larva was seen sticking to these bolls. A considerable number of the bolls were shed due to this damage.

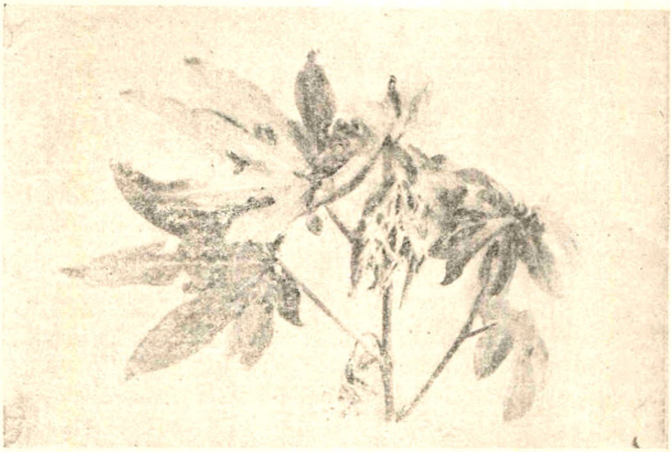

Fig. 1. Cotton plant showing damaged top shoot

The larvae moulted five times to reach complete development. During the months of July, August and September the larvae took 10 to 12 days for complete development and during the months of January and February this period was 15 to 19 days.

The larvae of *Earias fabia* exhibited marked colour variations. At Kanpur during the period of investigation four types of larvae were observed.

Pupae

Deshpande and Nadkarny (1936) reported that in Gujrat the pupae were invariably found in the soil. However, at Kanpur larger number of pupae were found on different parts of the plants, such as axils of leaves and between the calyx and corolla. The shape of the pupal cocoon was like a slightly wide boat with a raised notch at one end. The cocoon was whitish or slightly brownish in colour.

During the months of March-April, 1951 after the harvest of cotton, a soil sieving experiment was conducted. Eight pits, 3″ × 3″ and 8″ deep were dug in the field. These locations were selected at random. The soil from these pits was finely pulverised and sieved. The material remaining on the sieve was examined thoroughly for pupal cocoons. An average of two cocoons per pit were found to be present. On this basis a total of 9680 pupal cocoons per acre were calculated.

During the months of July, August, September and October the pupal period observed was 8 days (31 observations, range 4 to 15 days). During November and December an average pupal period of 28 days was observed (9 observations, range 18 to 31 days). In Gujrat Deshpande and Nadkarny (1936) have observed that the maximum duration of pupal period during December and January was 13 days.

Adults

The adults of all the three species were small moths with 3/4″ wing expanse. Some variation in the size of the adult moths was observed.

Earias fabia Stoll.—

Adult had a green wedge in the fore wing. The hind wing was membranous white. During the months of December and January straw coloured fore wings were observed in some specimens. The green wedge during this period was not so prominent in some specimens and narrow dark lines across the fore wing were observed.

Earias insulana Boisd.—

In a typical specimen, the fore wing was completely green. During the months of January and February, moths with lighter green to straw colour were also collected.

Earias cupreoviridis Wlk.—

The fore wing in this case was speckled with golden and brown spots at the base and the edge.

Storey (1914) in Egypt observed seasonal changes in the colour of the fore wing of *Earias insulana.* Mathur (1923) recorded the colour changes in the fore wings of this species in Punjab.

Habits of the adult moth and its longevity.—

The adult moth emerged out of the cocoon by making a longitudinal opening on the anterior side of the pupal cocoon. The adults fed on nectar and other juices of the plant and in the laboratory they were fed on sterilised dilute sugar syrup. Copulation occurred on the second or third night after emergence. Females were longer lived than the males. During the months of September and October the females lived for a period of 8 to 10 days and during the months of January and February for 25 to 28 days. Ahmed and Ghulamullah (1941) have studied the effect of temperature on the longevity of spotted bollworm moths. At 35⁰ C the moths survived for an average of 5·7 days and at 16⁰ C for 20 days.

SEASONAL HISTORY

Earias fabia and *Earias insulana* passed 6 to 8 generations during the whole year. Although these moths did not hibernate in any stage, it was observed that during the winter season the life cycle was considerably lengthened. *Earias cupreoviridis*, however, hibernated during the winter season as fully grown larvae. *Earias fabia* and *Earis insulana* after passing 3 to 4 generations on the cotton crop were attracted towards other malvaceous weeds after the harvest of the cotton crop. *Earias cupreoviridis* passed 4 to 5 genarations during the whole year.

During the months of March to October, out of a total of 223 moths, 101 were males and 122 females, giving a sex ratio (male=1) of 1:2. During the months of November to February, however, out of a total of 119 moths, 64 were males and 55 females, giving a sex ratio of 0:8. Thus during the winter months the biotic potential was reduced by a preponderance of males over females.

In order to see the seasonal abundance of the three species, an yearly record of adults reared from the larvae collected from cotton, *Gossypium* spp., Bhindi, *Hibiscus esculentus*, hollyhock, *Althea rosea*, *Malvestrum tricuspidatum* and *Sida cordifolia* was maintained. Out of a total of 311 moths reared for this purpose, 221 were *Earias fabia*, 82 *Earias insulana* and 7 *Earias cupreoviridis*. Thus at Kanpur, *Earias fabia* was the most abundant species.

Food plants and Alternative host plants.—

Earias fabia and *Earias insulana* confined themselves to the cultivated and uncultivated plants of the Malvaceae family. The main food plants of economic importance were, cotton, *Gossypium* spp., Bhindi, *Hibiscus esculentus*; Hollyhock, *Althea rosea*; and Patsan, *Hibiscus cannabinus*. Besides these the spotted bollworms were recorded from the following species of plants at Kanpur: *Abutilon indicum*, *Hibiscus ficulneus*, *Hibiscus rosasinensis*, *Hibscus sabda riffa*, *Malvestrum tricuspidatum*, *Sida cordifolia*, *Sida carpinifolia*, and *Urena lobata*. *Sida carpinifolia* has been recorded for the first time as an alternative host plant of *Earias* spp. *Earias cupreoviridis*, however, was recorded only from *Malvestrum tricuspidatum* and *Sida cordifolia*.

Extent of damage to cotton.—

A total of 18% buds (16 observations, range 8 to 30%), 15% flowers (15 observations, range 6 to 32%), and 13% bolls (14 observations, range 8 to 20%) were found to be damaged by spotted bollworms.

An analysis of the shed bolls, buds and flowers showed that 61% buds (9 observations, range 44 to 90%), 34% flowers (9 observations range 8 to 58%)

and 58% bolls (9 observations, range 40 to 90%) were damaged by spotted bollworms. It was concluded that the spotted bollworms took a heavy toll from the cotton growers in this region. Damage was done to all stages of the cotton plant, thus reducing the yield considerably.

NATURAL ENEMIES

Predators

During the course of this investigation, only one predator, *Cantheconidia furcellata* Wolff was recorded on the larvae of spotted bollworms. The adults and nymphs of this predator were very active during the months of August, September, October and November. The adults and nymphs fed on spotted bollworm larvae by sucking the body fluids with their proboscis. (Figs. 2 and 3).

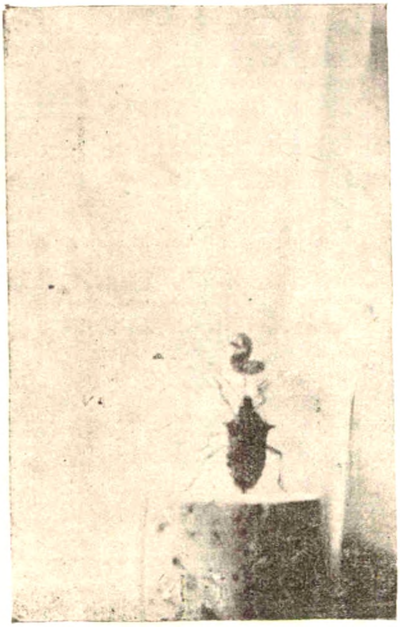

Fig. 2. Adult of the predator, *Cantheconidia furcellata* Wolf feeding on the spotted bollworm larva.

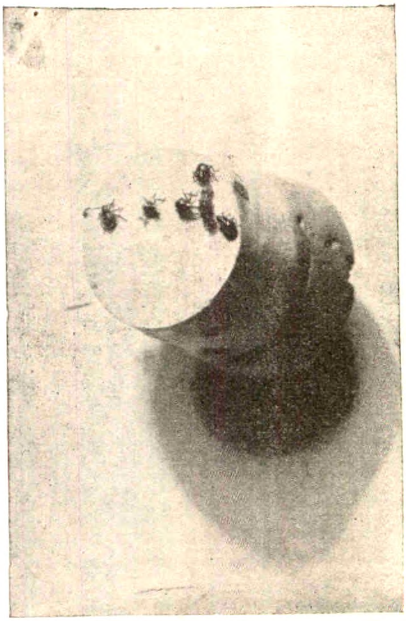

Fig. 3. Nymphs of *Cantheconidia furcellata* Wolf feeding on spotted bollworm larva.

Females laid eggs on the underside of the leaves of cotton in batches of 25-30. The shape of the egg was like a flower pot, the top bearing a lid fitted with a raised rim provided with small projections, slightly wider than the lower part. The young nymphs were reddish in colour with black head. After emergence from the egg they start feeding on the larvae of *Earias* spp. (Fig. 3) Sometimes 6 to 8 nymphs were found to be attached to one larva. In the laboratory a single nymph consumed 7 to 8 *Earias* larvae before reaching the adult stage. Each adult consumed 4 to 8 larvae every day in the laboratory. The everage life span of an adult was 8 to 9 days. Thus this was an important natural enemy of *Earias* spp. at Kanpur.

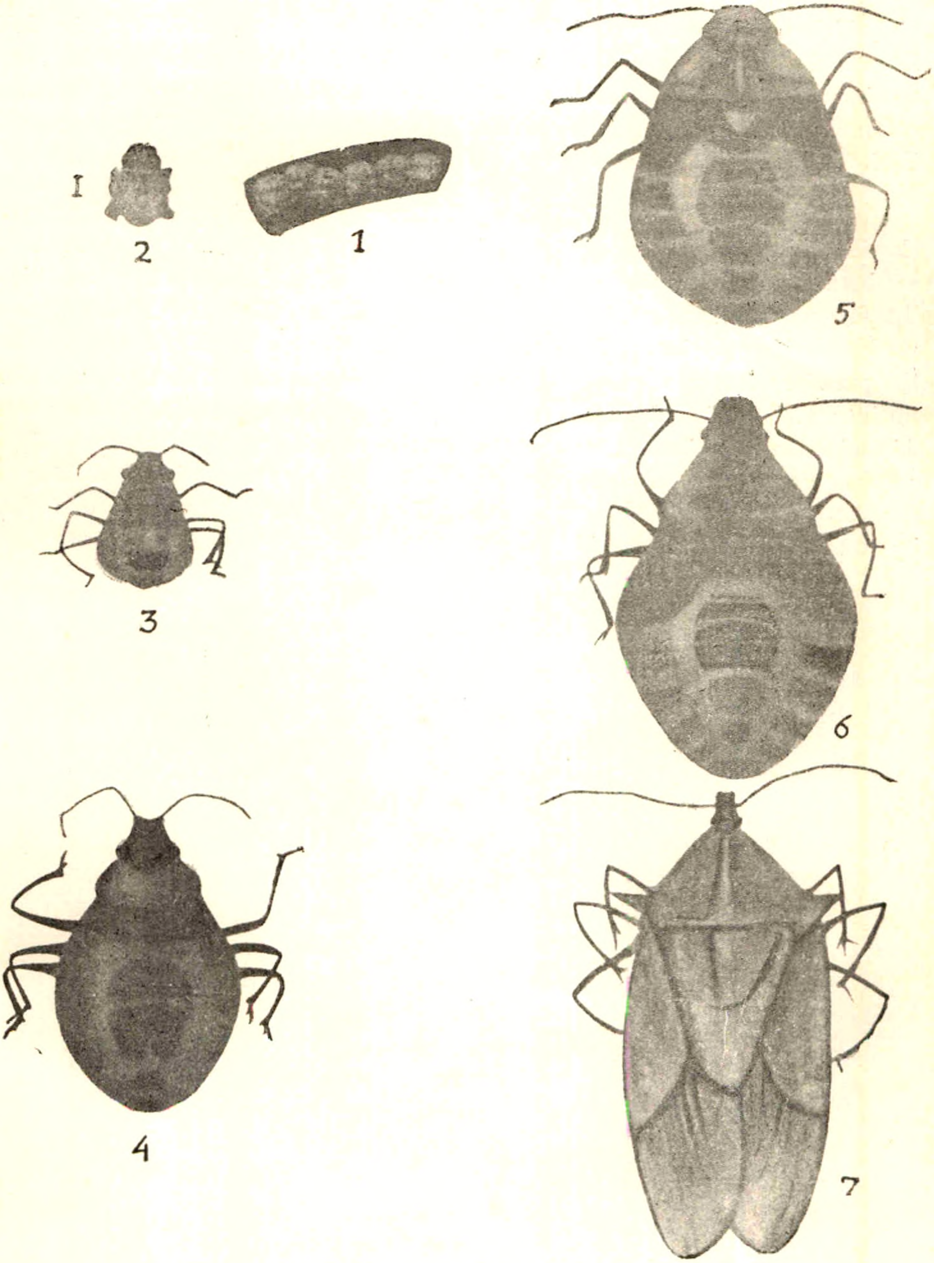

Fig. 4. Life history of *Cantheconidia furcellata* Wolff 1. Eggs. 2—6 Nymphs of different stages. 7 Adult. (×6)

Parasites

Larval Parasites

1. *Rhogas* sp.

This species was reared from parasitized larvae collected from the field. Dr. M. S. Mani, then of the St. John's College, Agra, identified it as a new species and gave the name *Rhogas Kanpurensis sp. nov.* He reported (personal communication, 1951) that this species was closely related to *Rhogas brevipalpis* End. from Ceylon.

Figure 5 shows the life history of *Rhogas* (*kanpurensis* sp.nov?) Eggs were slender and elongate, laid inside the body cavity of the spotted bollworm larvae in between the body wall and the mid gut. Under the laboratory conditions the full grown larvae were rejected for oviposition. Third instar larvae were preferred for egg laying . Only one egg was laid in one larva. After 6 to 8 days the parasite larva reached full grown stage. By this time it had consumed all the internal body tissues of the host larva. The parasite pupated inside the larval skin of the host. These appear as chitinous, brownish pupal cocoons. These cocoons were also collected from the field, where they were found sticking to the shoots and bracts of cotton plants. The adults emerged after 3 to 5 days by making hole on one side of the pupal cocoon.

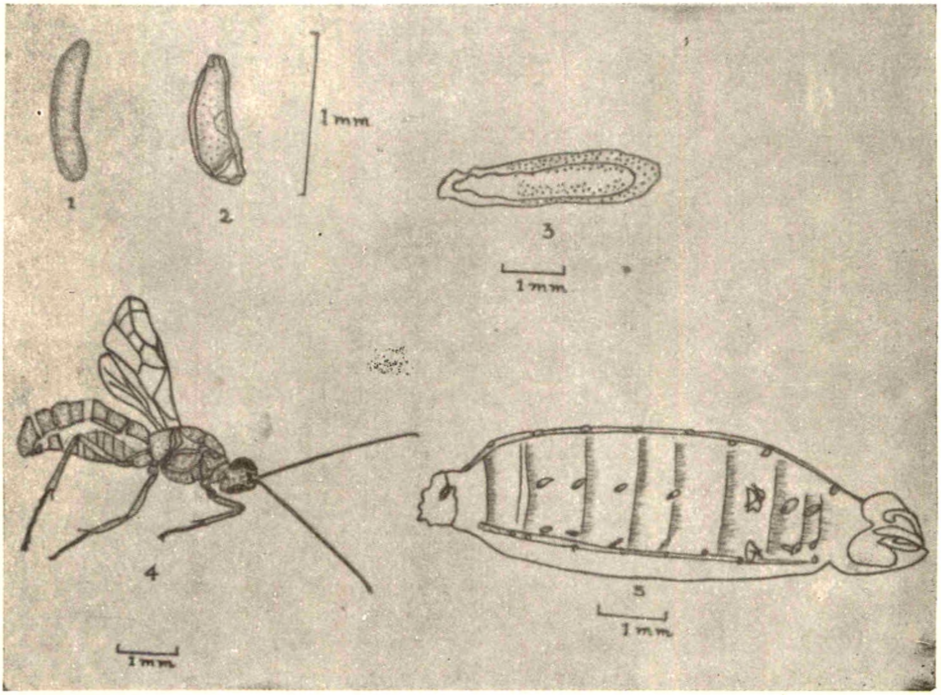

Fig. 5. Life history of *Rhogas sp.* (*kanpurensis* sp. nov ?)
1. Egg. 2. First stage larva 3. Full grown larva 4. Adult.
5. Pupal cocoon of the parasito formed inside the larval skin of the host.

During the months of July to November, out of a total of 175 larvae collected from the field 18 were found to be parasitized with this parasite.

2. *Microbracon greeni* Ash.—

This was recorded as an external parasite on the *Earias* larvae. After locating the spotted bollworm larvae inside a bud or a boll, the female inserted the long ovipositor through the hole made by the larva or by puncturing the soft plant tissue and laid eggs on the body surface of the larva. Larvae having more than one egg of this parasite were recorded from the field (upto 12 eggs). In the fruits of *Abutilon indicum* occurring as weed in this area, nearly 100% larvae were recorded to be parasitized by this parasite during the winter months of December to February.

3. An unidentified braconid, very similar to *Rhogas* (*kanpurensis* sp nov.) in life history was also recorded from the *Earias* larvae.

4. An unidentified Tachinid was also reared from the parasitized larvae collected from the field.

Pupal parasites.—

Two pupal parasites, *Brachymeria* sp. and *Melcha nursei* Cam. were reared from the parasitized pupae collected from the field.

ACKNOWLEDGEMENTS

This work constitutes a part of thesis submitted by the author in partial fulfilment of the requirements of Master of Science in Agriculture degree of the Agra University during the academic year 1951-52.

The author wishes to acknowledge the help of Dr. M. S. Mani, then of St. John's College, Agra and Dr. E. S. Narayanan, Head of the Division of Entomology, I.A.R.I., New Delhi for the identifications of parasites sent to them.

SUMMARY

Bionomics of *Earias fabia* Stoll, *Earias insulana* Boisd and *Earias cupreoviridis* Wlk. was studied at Kanpur.

Earias fabia and *Earias insulana* were found to be important pests of cotton, *Gossypium* spp. Bhindi, *Hibiscus esculentus*, Patsan, *Hibiscus cannabinus*; and hollyhock, *Althea rosea*. The type and extent of damage by these insects has been described.

Life history of a predator, *Cantheconidia furcellata* Wolff. has been studied. A new internal parasite, *Rhogas* sp. (*kanpurensis* sp nov?) was recorded and its life history was described . An external larval parasite, *Microbracon greeni* and two unidentified parasites, a Braconid and a Tachinid were also recorded from the larvae. Two pupal parasites , *Brachymeria* sp. and *Melcha nursei* Cam. were also recorded.

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DISTRIBUTION OF VITAMIN C IN THE OOGENESIS OF *MYLABRIS PUSTULATA* (THUNB.) (COLEOPTERA)

By UDAI VIR, M.Sc., *Department of Zoology & Entomology, St. John's College, Agra.*

INTRODUCTION

The distribution of vitamin C granules has been studied by many cytologists in various species from time to time. Giroud and Leblond (1936-37), Tonutti (1937), Deane Hirsch (1937), Miwa (1939), Barnett and Bourne (1942), Deane and Morse (1948) and recently Prasad (1953) have made important contributions to the study of cytology by describing the distribution and role of vitamin C in different tissues and cells of various animals.

The studies on the distribution of vitamin C in the oocytes of some common insects have been sadly neglected. The purpose of this paper is to focus the attention on some of the newer and more significant aspects of distribution of vitamin C granules in the process of oogenesis of *Mylabris pustulata*, a common beetle.

MATERIAL AND METHOD

The material for the investigation was obtained late in August from Dayalbagh, Agra. The alive beetles were dissected to avoid the post-mortem changes. Immediately after removing, the ovaries were fixed in a mixture containing the following :—

Distilled water		50 c. c.
5% Acetic acid	...	5 c. c.
Silver nitrate	...	0·5 gm.

The material was fixed in a clean glass vessel covered with black coat for 24 hours. After fixation, the material was washed in distilled water, dehydrated and imbedded in paraffin wax of 56°—58° grade in the usual manner and the sections of 4-6 micra thick were cut. Finally the sections were mounted in canada balsam in the usual way and examined carefully under the phase-contrast microscope. The figures were drawn with the help of Camera lucida.

OBSERVATIONS

The egg is oval in shape and is completely enclosed in an envelope. The outer most layer the chorion (Fig. 1, CH) is tough, thin and elastic in nature. Below the chorion lies the structureless vitelline membrane (Fig. 1, VIT) which encloses the granular periplasm (Fig. 1, PER). The periplasm contains the nucleus (Fig. 1, NU) almost at the middle, with quite prominent nucleolus

(Fig. 1, NUC), which diminishes in size as the advancement of the egg proceeds further. Nucleus is surrounded by a relatively thicker layer of periplasm.

In a very early oocyte the vitamin C is seen in the form of black granules which become aggregated at the juxta-nuclear position (Fig. 2, VITC). The next stage is followed by the tendency of the vitamin C granules dispersing in such a manner as to form a partial ring around the periphery of the nucleus (Fig. 3). With the further advancement of the oocyte the vitamin C granules become scattered uniformly throughout the yolk (Fig. 4). At this stage the granules are black and comparatively smaller than their previous size and exhibit a more roundish outline. The pattern of uniform distribution of granules is soon transformed into one of few clusters which become restricted to one side of the egg. Besides these clusters more granules retain their uniform distribution in the yolk. But this is, however, confined only to the region of the cell opposite to the one occupied by the clusters (Fig. 5). A still more advanced oocyte shows the migration of vitamin C granules towards its periphery. There is slight deviation from the usual peripheral stage and the granules here show concentration on only one side of the peripheral yolk. In this stage the size of the granules appears to be larger than it was before (Fig. 6).

DISCUSSION

The earlier workers suffered a series of setbacks in developing a technique for the demonstration of vitamin C in microscopic preparations, chiefly because of its solubility in alcohol and water. It was as late as 1928, when Szent Györgyi in his investigations showed that ascorbic acid is the only substance in protoplasm that has a particularly strong reducing action on silver nitrate. This important observation led the earlier workers to use a mixture of ethyl alcohol and aqueous silver nitrate, but this technique did not preclude the confusion likely to be created as a result of the possible action of silver nitrate on Golgi elements. This reagent was, therefore, further modified by Giroud and Leblond (1934) who replaced the ethyl alcohol by acetic acid and thus made the fixative more specific for the demonstration of vitamin C in cells which appeared in the form of a black precipitate of metallic silver.

Barnett and Bourne (1942) pointed out in their extensive studies on chick embroys that although the technique of acid silver nitrate has proved specific for the demonstration of ascorbic acid in glandular tissue, its results can always be confused with that of usually obtained by the application of a technique for the demonstration of Golgi elements.

Barnett and Fisher (1943) have maintained that the presence of ascorbic acid in microscopical preparations brings about precipitation of metallic silver in the form of black granules. It has been observed to be oriented on or in the Golgi material.

Deane and Morse (1948) in their cytological studies in the rat's adrenal cortex have pointed out that rapid and delayed fixation materially effect results. The former materialises uniform distribution of granules of reduced silver in the cytoplasm and the latter accumulation of granules in a juxta-nuclear position in the Golgi zone. The need for quick fixation is emphasized by the authors in order to ensure better preservation of cellular substance as also the chance of reduction to a minimum of the post-mortem changes.

Giroud and Leblond (1935) and Tonutti (1937) made observations to the effect that vitamin C is localised within the Golgi apparatus and is subsequently absorbed therein. But the author in the problem under investigation is of the opinion that the vitamin C granules are distinctly larger in size to the Golgi apparatus commonly met with among insects and should, therefore, be treated as independent cellular inclusions living in close and intimate association with the Golgi apparatus.

SUMMARY

1. The distribution of Ascorbic acid (vitamin C) in the oogenesis of *Mylabris pustulata* has been studied by the acid silver nitrate method.

2. The vitamin C granules are distributed throughout the yolk in various patterns, in successive stages of development. Histologically the vitamin C granules are black and roundish in appearance.

3. First of all the vitamin C granules accumulate on one side of the nucleus forming a juxta-nuclear stage. The granules appear in the primitive form and are also smaller in size comparatively to other stages.

4. The granules have a tendency to take their position around the nucleus forming peri-nuclear stage.

5. In the following stage the vitamin C granules are uniformly distributed in the yolk and appear to have still smallar size. The next stage is followed by the formation of clusters all along the yolk especially at the one end of the cells.

6. The vitamin C granules are distinctly larger in size than the Golgi apparatus commonly met with among insects.

ACKNOWLEDGMENT

It is a pleasure to record my grateful thanks to Dr. Vidya Nand for suggesting the problem, for advice and thoughtful criticism. My sincere thanks are also due to Dr. T. Singh for providing me the necessary facilities in the department and to the Scientific Research Committee, U. P. for financial help.

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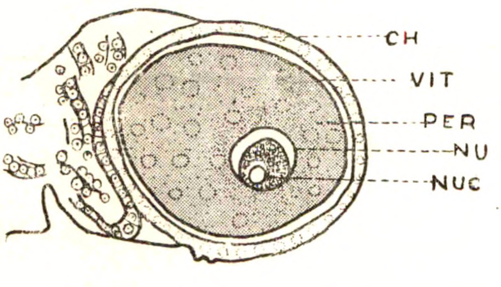
LETTERING

CH - Chorion.
VIT - Vitelline membrane.
PER - Periplasm.
NU - Nucleus.
VITC - Vitamin C granules.
YK - Yolk.



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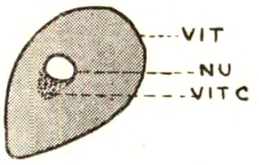

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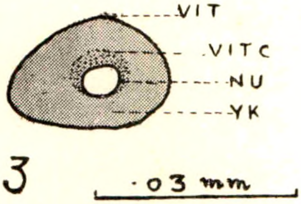

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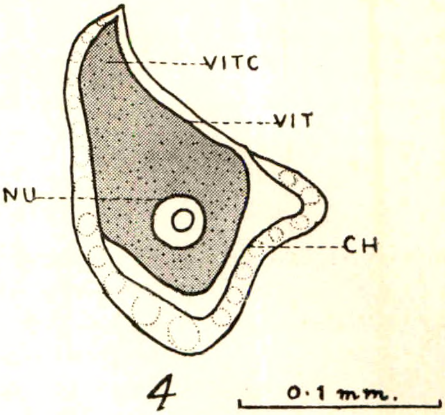

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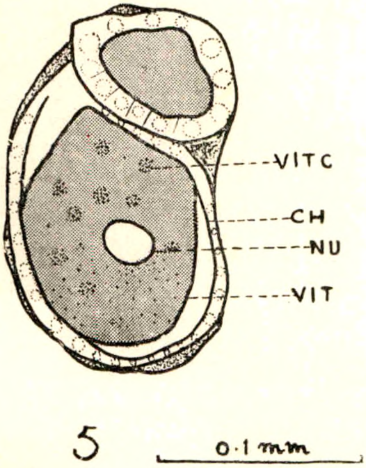

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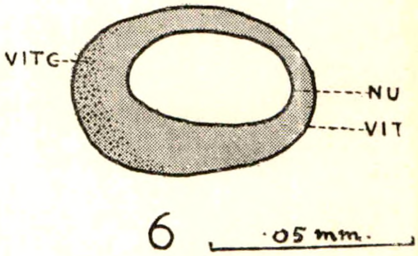

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EXPLANATION OF PLATE

Fig. 1. T. S. of the ovarian egg showing the general structure.

Fig. 2. A very early oocyte showing the Juxta-nuclear mass of vitamin C granules.

Fig. 3. Oocyte showing the partial peri-nuclear ring stage of vitamin C granules.

Fig. 4. Slightly advanced oocyte showing the uniform distribution of vitamin C granules.

Fig. 5. The vitamin C granules are arranged in clusters in the anterior region of the egg.

Fig. 6. An advanced oocyte showing peripheral arrangement of the vitamin C granules.

MORPHOLOGY OF THE HEAD CAPSULE OF *ASPONGOPUS JANUS* FABR.

(PENTATOMIDAE : HETEROPTERA)*

By L. G. Banerji, M. Sc., *University Research Scholar, School of Entomology, St. John's College, Agra.*

Contents

	Page
1. Introduction	47
2. Material and Method	48
3. Head Capsule	48
(i) Post occiput	
(ii) Occiput	
(iii) Frons	
(iv) Clypeus	
(v) Mandibular plate	
(vi) Maxillary plate	
(vii) Labrum	
(viii) Gena	
(ix) Gula	
(x) Antennae with their muscles	
4. Mouth parts	52
(i) Labium with its muscles	
(ii) Mandibular stylets with their muscles	
(iii) Maxillary stylets with their muscles	
(iv) Hypopharynx with its muscles	
(v) Salivary syringe with its muscles	
5. Summary	57
6. References	57
7. Abbreviations	58
8. Explanation of figures	60

Introduction

Aspongopus janus Fabr. is a sporadic pest on some cucurbitaceae throughout India. In certain cases it causes extensive damage to the plants by sucking their sap, which results very often in their complete destruction. In view of its notorious activities, it was felt that a detailed study of the head capsule and the mouth parts would reveal information of considerable fundamental importance. Though morphology of head capsule of Hemiptera has attracted the attention of various workers abroad, our knowledge about Indian forms is fragmentary. Besides Snodgrass (1921, 1935, 1945), Du Porte (1946), Butt (1943), Evans (1946), Ferris (1943, 1947) and Qadri (1948, 1950) who concentrated on Homoptera and compared the homologies of various parts in Hemiptera as a whole, only other work of importance in Heteroptera is by Hamilton (1931) on *Nepa cinerea*, Mac Gill (1947) on *Dysdercus intermedius* and Akbar (1957) on *Leptocorisa varicornis*. The present investigations were undertaken as a part of a more comprehensive work on the morphology and anatomy of *Aspongopus janus* Fabr. The detailed account of the digestive system will follow in the near future.

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MATERIAL AND METHOD

Adult *Aspongopus janus* were collected in the months of July to September from the plants of *Lagenaris vulgaris* and *Cucurbita pepo*. The insects were preserved in 90% ethyl alchol. External sclerotic portions and sutures of the head were determined by studying under the binocular. The head was boiled in 10% KOH for transparency of highly chitinised structures. Teased specimens were found to be useful for examination of each sclerotic area. Details of the mandibular and maxillary stylet were studied under phase contrast and oil imersion of the ortholux microscope. Throughout the studies dissections were the main technique which were done in Ringer's solution after narcotising the specimens with ethyl aether replaced by freshly prepared Bouin's fluid and finally by 70% alcohol. Mallory's tripple stain method of Alam (1951) was adopted for the study of musculature. The figures were made from dissected specimens and slide preparations by the help of Camera Lucida.

HEAD CAPSULE

The Head is conical, a little produced anteriorly with flattened and corrugated dorsal surface. Colour is predominently black with dark-brown gular regions. Posteriorly it is covered by the anterior margin of the prothorax upto the eyes infront. The antennae arise from the sides of the head, from near the base of the mandibular plates. A distinct pair of ocelli are present on the frontal region. The sclerites are so well welded together that it is difficult to distinguish the sutures.

Post-occiput.—The post-occiput is a raised chitinous ring with post occipital suture distinct on dorso-lateral sides of the occipital foramen (Figs. 1 & 7, PO, POS). Post-occipital suture is represented internally by a post-occipital ridge. The triangular occipital condyle is situated on the ventro-lateral aspects of the post-occiput (Fig. 7, OL). Posteriorly the post-occiput is connected to the prothorax by feebly chitinised, flexible, transparent membrane which provide freedom of movement for the head capsule.

Occiput.—Occiput is clearly marked off by an incomplete occipital suture from the rest of the epicranium and is normally telescoped inside the prothorax behind (Figs 1, 2, OC, OCC). The occipital suture begins from the posterior margin of the compound eye running anteriorly to end below the ocelli ; internally it is represented by well developed internal ridge (Figs. 16, 18, 1 9, OCX) which provides insertion for retractor muscles of mandibular stylets and antennae.

Frons.—Epicranium and frons are fused together without leaving any traces of suture in between them. Frons is represented by a raised up portion bearing two prominent ocelli and extends between the two compound eyes (Fig. 1, F). The compound eyes are well developed, prominent, globular and bear distinct ocular sclerites dorso-posteriorly (Figs. 1, 2, 3, E, OCS, OS) with ommatidia restricted to the anterior three-fourths of the surface. Evans (1938, 46, 57) regards frons as distinct cephalic sclerite while Ferris (1943) considers it as facial portion of the antennal segment. Du Porte (1946) and Snodgrass (1947) believe that frons has no anatomical status, since epicranial suture is without structural significance. According to Imms (1935) the expression frons is very often used to describe this region although it is not definitely marked off from epicranium. Sondgrass (1947) on *Ormenis pruinosa* and Qadri (1950) in *Pyrilla perpusila* hold the view that the best criterion for identity of frons should be the line of cleavage during the last moult of the nymph.

Clypeus.—The clypeus is a small anteriorly placed sclerite, fused basally to the frons and attached anteriorly to the labrum through a transverse membrane. Though it is not defined by sutures posteriorly, the clypeus extends far back on the dorsal surface of the head (Fig. 1, PCL). Snodgrass (1935) also reports this extension of the clypeus on to the dorsal surface of the head since dialator muscles of the sucking pump originate from this area.

Clypeus is divisible into a wide proximal postclypeus and a narrow almost triangular ante-clypeus distally. Though there is no suture between the ante-clypeus and post-clypeus but according to Southwood (1953) the division is considered to occur where the clypeal folds end. The ante-clypeus is bounded laterally by deep clefts which demarcate it from the lateral lobes or the mandibular plates (Fig. 1, CLC). These clefts are referred to as 'clypeal folds' by Mac Gill (1947) and are represented internally by prominent ridges. Anteclypeus narrows and slopes down antero-ventrally to join the labrum. The mandibular plates meet together antero-mesally to cover the anteclypeus so as to render it invisible infront. Antero-laterally the clypeus is inflexed to meet ventrally along a mid-ventral line and enclose a cavity through which the stylets pass (Figs. 8, 9, CR). There seems to be a great confusion in literature regarding the terminology of the clypeus. Various authors have designated clypeus by various names such as clypeus by Myers (1928), Hamilton (1931), Mac Gill (1947), Qadri (1950), Akbar (1957); anteclypeus by Butt (1947); clypeolabrum by Muir (1926) and tylus by Snodgrass (1935).

Snodgrass (1935) considers clypeus as that region from which the dilators of the sucking pump originate and frons from where the pharyngeal dialators arise. Since no definite boundary between pharynx and sucking pump could be established it was not possible to say where cibarium ends and pharynx begins. Again Snodgrass (1947) points out that the dorsal cibarial dialators originate on the clypeus and are inserted on the foregut anterior to the frontal ganglion; the pharyngeal dilators, on the other hand, originate on the frons and become inserted in the pharynx within the loop formed by the frontal ganglionic connectives. According to Duporte (1956) the region of the sclerite ventral to the tentorial pits pertains to the frons while Snodgrass (1947) considers frons as an indefinite region dorsal to the clypeus. Since in *Aspongopus janus* the tentorial pits are entirely absent the demarcation of the frons has been decided on the basis of muscle origin.

Mandibular plate.—Mandibular plates lie on either side of the clypeus separated from ante-clypeus by clypeal clefts (Fig. 1, MDPL.) They are produced anteriorly so as to completely envelop the anterior portion of the clypeus. The produced anterior portion is deflected downwards and is visible on the ventral side of the head anterior to the maxillary plates from which it is separated by a mandibulo-maxillary groove laterally and ventrally (Fig. 3, MDPL, MG). Laterally the mandibular plates join with the genae (Fig. 2, GE). A faint pleurostomal suture starts from the place where the clypeal cleft ends and runs ventrally up to the base of antenna (Figs. 1, 2, 3, PLS). Muir & Kershaw (1911), Imms (1935) called it frontal ridge ; Borner (1935) called it genea or cheek wings (Oberkieferlappen) while Knight (1941), Mac Gill (1947), Newcomer (1948), Southwood (1953) termed it jugum; Spooner (1938) named it as paraclypeus while Myers (1928), Hamilton (1931), Butt (1943) and Snodgrass (1944) called it lorum. Muir & Kershaw (1912), Evans (1938), Spooner (1938), Ferris (1943) regard mandibular plate as lateral extension of post-clypeus while Myers (1928) and Weber (1933) regard it as part of gena. Qadri (1950) and Akbar (1957) called it an independent subgenal sclerite or pleurostoma.

Lorum is a triangular, sclerotised plate placed vertically on either side of the clypeus along the inner margin of the mandibular plates. It runs exactly dorso-ventrally and meets the hypopharynx at its antero-dorsal surface. The loral plate is slightly sinuate posteriorly and obtusely produced anteriorly (Fig. 18, 20, LO). Qadri (1950) and Akbar (1957) consider it as an independent sclerite different from mandibular plates. The author, however, is tempted to accept Qadri's view because the mandibular plates cannot be an extension of clypeus as a well developed clypeal groove is present and they cannot be a part of genae as well due to the presence of pleurostomal suture.

Maxillary plate.—Oval area between buccula and the antennal base represents the maxillary plates (Fig. 18, 20 : MXPL). Anterodorsally and laterally it is bounded by mandibulo-maxillary groove from the mandibular plate while posteriorly it merges with the gula (Fig. 2, 3; M. G.). At the inner angles of the anterior side, the maxillary plates are produced into pulley-like maxillary processes. Two processes of either sides meet mesially to complete a pulley on which the stylets rest before entering the labium (Fig. 20; MXPR).

Two small sclerites attached by their proximal ends to the inner aspects of the maxillary plates represent the bucculae (Fig. 3, 7; BU). They comprise semicircular pieces bordering the membrane by which the labrum is attached to the clypeus. Bases of the two bucculae are fused together while the distal ends are free and partially overlap the base of the labium. Akbar (1957) considers bucculae to owe their origin from the corresponding maxillary plates.

Labrum.—Labrum is a narrow triangular piece broad at the base and tapering gradually towards distal end reaching upto the middle of the second labial segment (Fig. 3, 8, 9, LR). Basally it is attached to the antero-ventral end of the ante-clypeus by a transverse membrane (Fig. 9, M). Dorsally its crinkled nature gives it a segmented appearance while on the ventral surface it is smooth and forms a hollow groove which serves as a lid on the proximal end of the labium (Fig. 8; LRG). Basal one-third is heavily chitinised and pigmented but the distal two-thirds represent a feebly chitinised flap. The hollow grooved ventral surface guides the stylets after their emergence from the clypeus, into the labium at the second labial segment. Butt (1943) records the existence of flange and ridge in the labral groove and outer surface of mandibular stylet during his investigations on *Notonecta*. In the present studies, however these structures are absent.

Gena.—The genae are placed between the antenna and compound eye. Posteriorly it merges with the gula while dorso-anteriorly it is separated from the mandibular plate and the antennal base (Fig. 2, 7; GE).

Gula.—Gula is well developed and stretches ventrally between the base of the labium infront and occipital foramen behind (Fig. 2, 7 ; GU). About half of the gula is telescoped inside the prothorax. The hidden portion being distinguishable by its yellowish-brown colour while the portion outside the prothorax is heavily chitinised and deep brown in colour.

Antenna.—Antennae are simple, filiform, five segmented and inserted on the ventrolateral aspect of the head on the genal plate (Fig. 4, 5). The terminal segment is the longest, a little less than as long as the combined fourth and third segments, and three times as long as the scape or first antennal segment (Fig. 4; FL3) ; 4th segment one and a three-fourths as long as the 3rd; 3rd segment a little more than half as long as the second segment or the pedicel ; second antennal segment almost equal to the 4th and a little more than twice as long as the basal segment or the scape (Fig. 4; PD) ; basal segment shortest, 1/11th as long as the entire antenna and one-third of the terminal segment (Fig. 4; SC). The first antennal segment or the scape is broken up into another small feebly chitinised basal segment or the basal scape, which is lodged in the antennal socket (Fig. 5; BS). The basal scape is chitinised ventrally while dorsally it is membranous. The basal scape is attached to the rim by a membrane which is loose on the dorsal and lateral side so that the antenna can move freely in the dorsolateral direction. Distally the basal scape is rigidly joined to the proximal end of the scape.

Musculature of Antenna.—The antennal musculature comprises a pair of extrinsic muscles and another pair of intrinsic muscles.

(a) Extrinsic muscles.—

(i) *Levator of Antenna.* (Fig. 16 ; RN).—This muscle takes its origin from the anterior portion of the occipital ridge slightly antero-mesially to the eye and converges latero-ventrally into a tendon to be inserted on the dorsal apodeme of the basal scape. Its contraction brings about upward movement of the antenna.

(ii) *Depressor of Antenna* (Fig. 16 ; RN).—This represents a stouter and stronger muscle than the levator which originates from the occipital ridge posterior to the origin of the levator. The fibres converge ventro-laterally to be inserted on the ventro-mesial apodeme on the rim of the antennal base. This muscle functions as an antagonistic to the levator muscle and its contraction depresses the antenna.

Akbar (1957) describes a second set of antennal depressor which arise from the mid-cranial ridge and become inserted on the side of the apodeme on the rim. No such muscle has been found in *Aspongopus janus.*

(b) Intrinsic muscles.—

(i) *Levator of pedicel* (Fig. 17 ; LE).—It is a stout pinnate muscle originating basally from the dorsal wall of the scape and inserted on the dorsolateral sides of the basal rim of pedicel. Contraction of this muscle causes the inward and upward movement of the antenna.

(ii) *Depressor of pedicel* (Fig., 17;DE).—It is comparatively a weak muscle which arises over a considerable area of the ventral wall and converges to be inserted through a tendon on the ventro-lateral portion of the pedicel rim. The outward and downward movements of the antennae are caused by the contraction of this muscle.

Mouth Parts

The mouth parts are typically of piercing and sucking type. They comprise a tubular labium, a pair of mandibular stylets, a pair of maxillary stylets and a complex hypopharynx.

Labium.—The ventrally placed labium is elongated, four segmented, cylindrical, slender, bent at the middle (Fig. 6, 7). When not in use it lies against the prosternum extending upto procoxae.

Edges of the proximal three segments are rolled upwards and slightly curved mesially to enclose a groove which is roofed over by a narrow triangular labrum along the first two segments. In the terminal segment the lateral edges meet together mesially to form a complete tube. The lining of the labial groove is thinly chitinised.

Basal segment is broad and is about twice as long as thick ; second segment longest and one and a half times as long as the first, widening apically ; penultimate segment shortest with a deep notch ventrally near the proximal margin, distally swollen; the terminal segment cylindrical, tapering distally. On superficial examination the labium seems to originate from the anteclypeus but a careful observation exhibits its origin from the anterior margin of the gula, from the antero-ventral margin of the head. Laterally it is bounded by bucculae while posteriorly it continues as a transverse thin membrane to join the gula, the membrane facilitates flexibility and movement (Fig. 6 ; M). There is a well defined carina along the lateral sides of the labium excepting the basal segment. Lateral and dorsal sides of the labium and the terminal tip are provided with sensory bristles.

The musculature of labium is represented by five intrinsic and a single extrinsic muscle.

Abductor of Labium (Fig. 22, 24 ; AB,).—Dorsally placed muscle originating from the proximal end of the 1st segment is attached to the posterior rim of second segment. Such muscle has been shown by Butt (1943) in *Oncopellus*, Kemper (1932) in *Cimex* and Akbar (1957) in *Leptocorisa*.

First intrinsic adductor (Fig. 22, 24 ; IA).—This muscle is placed mesially and runs parallel to the labial groove. It originates from the postero-dorsal wall of the first labial segment converging dorso-ventrally, inserted on the antero-ventral corner of the first segment.

Second intrinsic adductor (Fig. 24 ; IIA).—It is a long muscle, originating from the anterior rim of second segment and inserted on the posterior rim of the same segment. It is slightly broader anteriorly.

Flexor (Fig. 24; FX).—A thick muscle running antero-ventrally from the dorsal side, originates on the postero-dorsal wall of the terminal segment and runs ventro-posteriorly to be inserted on the ventral wall of the third segment.

Extrinsic adductor (Fig. 22, 24 ; EA).—Originating from the ventral portion of the hypopharynx it runs anteriorly and is attached on the ventral wall of the posterior rim of the second segment.

Mandibular Stylets.—A pair of long bristle-like structures constitute the mandibular stylets and form the outer pair of the four piercing organs. Basally a mandibular stylet is broad which tapers distally into a thin bristle to end into a lanceolate tip (Fig. 14, 15). Basal portion of the mandibular stylet slides over the mandibular sheath within the cranium. The proximal wide base is round and is produced into two distinct but short triangular processes (Fig. 14, K_1, K_2). The edge between these processes provides place for insertions of retractor muscles R_1 and R_2 which originate on the occipital ridge and postoccipital ridge respectively (Fig. 14; R_1, R_2). Mesially from the basal margin of the stylet between the two triangular processes arises a strong elastic tendon which after running along the mandibular stylet gets attached to the inner end of the mandibular lever (Fig. 14 ; TN). The mandibular lever is a triangular sclerotised plate, lying vertically to the plan of the head capsule (Fig. 18, 19 ; MDL). The outer angle of the mandibular lever is attached to the portion of the mandibular plate at its junction with the maxillary plate (Fig. 19 ; G). There is a great deal of variation in the attachment of lever ; such as Hamilton (1931) points out that the lever is attached with the genal suture, Butt (1943) considers the attachment to be mesal and infront of antennal fossa, Qadri (1950) describes the attachment on the epistomal suture and Akbar (1957) shows that its outer end is connected with cranium at the pleurostomal and epistomal ridges. From the proximo-mesial portion of the mandibular stylet base arises a coiled glandular structure which opens at the base between K_1, K_2 and represents the mandibular gland (Fig. 14 ; MDG). The inner edges of stylets are produced into ridges in the form of a plate with comb-like ridges projecting anteriorly from about 1/8th portion of the length of the stylet (Fig. 15 ; C). This inner plate is less chitinised and is almost as broad as the breadth of the main body of the stylet. This plate is broken, forming two anteriorly directed tooth-like projections (Fig 15 ; NS). The five tooth-like serrations on the outer edges of the mandibular stylet tip are directed backwards (Fig. 15 ; S). Mandibular stylets are smaller in length than the maxillary stylets.

Musculature of Mandibular stylet.—

1. *Retractor muscles of the mandibular stylet.*—The retractor muscles of mandibular stylet consist of two unequal bundles. The first bundle arises from the lateral sides of the post-occipital ridge. This is a thick and powerful muscle which is inserted on the base of the stylet (Fig. 18 ; R_2). The second muscle bundle is smaller and weaker, arises from the occipital ridge and gets inserted on the base of the stylet (Fig. 18 ; R_1).

2. *Protractor muscles of the mandibular stylet.*—A single protractor muscle originates in two bundles, the one placed dorsally originates from the dorsal surface on the mandibular plate (Fig. 18 ; MP_1., MP_2), the lower bundle originates partly from the dorsal and partly from the ventral plates. The protractor muscle is inserted on the broad base of the mandibular lever.

Maxillary stylets.—Maxillary stylets are slender thread-like structures with finely pointed tip and are placed ventro-mesially to the mandibular stylets. Along the inner margins the maxillary stylets are thrown into longitudinal grooves, each of the groove being partitioned by a longitudinal ridge running all along the length of the stylet (Fig. 13 ; N). The ridges of the grooved stylets converge together as they reach the hypopharynx and become locked up so as to enclose two longitudinal canals of unequal diameter. The dorsal canal constitutes the food canal and the ventral forms the salivary canal which at its proximal end receives the salivary syringe while the food canal communicates with the sucking pump. At the inner side near the base of the maxillary stylet there is a chitinised horse-shoe-shaped structure, the maxillary lever (Fig. 11; MXL). The maxillary lever is attached ventrally to the base of the maxillary stylet and curves over the base of the stylet to end dorso-laterally to the stylet. The free dorso-lateral end of the lever is attached to the anterior process of the wing of the hypopharynx and serves to hold the maxillary stylets in position (Fig. 25; Z). On the inner margins are a set of inter-locking mechanisms in the form of triangular ridges between the two maxillary stylets (Fig. 10, 12; H-J). At the terminal region, on inner sides, the maxillary stylets are slightly depressed (Fig. 13 ; X). The median ridge of the maxillary stylet starts from the very base of the stylet and ends at the tip (Fig. 11, 13 ; N). No serrations could be found on the maxillary stylets. Such interlocking arrangements have been reported by Qadri (1950) in *Idiocerus* sp.

Musculature of maxillary stylet.—

1. *Retractor muscles of maxillary stylet.*—There is a single thick and strong retractor muscle bundle which arises from the post-occipital ridge and gets inseretd on the base of the maxillary stylet (Fig. 20; MXR).

2. *Protractor muscles of maxillary stylet.*—Three sets of muscles are responsible for the protraction of the maxillary stylet. The first bundle originates from the antero-lateral sides of the maxillary plates (Fig. 20 ; 1). The second bundle from the antero-lateral margin of maxillary process (Fig. 20; 2); the third from the sides of the hypopharynx at the antero-ventral sides (Fig. 20 ; 3).

Hypopharynx.—Hypopharynx is an elongated chitinised structure anteriorly produced into a pointed beak and narrow at the middle but broadend out posteriorly (Fig. 29). On either side it bears thin chitinised plate, the hypopharyngeal wings (Fig. 29; WHY). Posteriorly the wings are produced into acute angles which are attached to the post-occiput by chitinised stout tendons (Fig 25, 29 ; Z_2). Latero-ventral margin of the wing is convex which anteriorly bears small process through which it is attached with gena (Fig.25, 29; Z_1). Anteriorly the wings are produced into chitinised processes which meet together to form a bridge and provide support for the salivary syringe from below (Fig. 26 ; PL). Anteriorly the hypopharynx bears a pair of triangular chitinised plates called the antero-dorsal processes. Dorsally these processes are attached to the loral plates in a vertical plane, and loral plate in turn joins with the cranium (Fig. 29; AHY).

The floor of the hypopharynx is thrown into longitudinal, shallow, median groove forming the floor of the sucking pump, which continues posteriorly into pharynx (Fig. 29 ; CB, PH). Antero-ventrally the salivary syringe is attached to the hypopharynx.

Hypopharyngeal salivary syringe.—The salivary syringe is situated beneath the median process between the two maxillary stylets, at the mid-ventral line of the hypopharynx. It consists of a diaphragm, piston and handle. A median plate formed by the two wings at the anterior end holds the syringe from the ventral side (Fig. 26 ; PL).

The diaphragm (Fig. 28 ; D) is cylindrical, chitinous and transparent. When we try to detach it from the hypopharynx, it breakes clearly off from the posterior side at the end of the piston. It is produced into a beak-like anterior region (Fig. 27 ; B). There is an exit duct for the exit of saliva into the maxillary duct (Fig. 28 ; ED). The common duct of the salivary gland opens on the ventral side of the diaphragm into the cavity of the syringe (Fig. 27; CSD ; CA).

The piston (Fig. 28 ; P) is round, black and highly sclerotised structure. The handle of the piston is a leaf like dorso-ventrally flat structure bearing on its flat surface the retractor muscles of the salivary syringe (Fig. 27, 28 ; PR). A chitinous flexible posterior lever-spring brings the piston to its normal position after relaxation of the retractor muscles of the salivary syringe.

The salivary duct from the salivary gland comes beneath the syringe and the common salivary duct opens into the ventral side of the salivary syringe at about the middle of the length of the syringe diaphragm (Fig. 27 ; SD ; CSD). Anteriorly the syringe is produced into a fine tip.

Measurements of salivary syringe :

1. Length of the salivary syringe	0.205 mm.
2. Length of the rod of piston	0.8 mm.
3. Breadth of the salivary syringe	0.09 mm.
4. Breadth of the piston inside salivary syringe	0.04 mm.

Musculature of salivary syringe :

The retractor muscles of the salivary syringe originate chiefly from the hypopharyngeal wings (Fig. 27 ; RPS_1) but a few posterior muscles originate on the gular plate (Fig. 27 ; RPS_2). These muscles are placed parallel to each other and inserted on the leaf-like handle of the piston.

Epipharynx is a narrow, extensible, chitinised, transparent membrane forming the roof of the sucking pump. The dilator muscles of the sucking pump are attached on its dorsal surface (Fig. 23 ; EP).

Cibarial muscle :

(a) *Dilator muscle of the cibarium or sucking pump* (Fig. 21, 23, 25 ; CD). A large bundle of muscle originating from the clypeus is inserted on the epipharynx, which forms the dorsal wall of the sucking pump.

(b) Dilator muscles of the pharynx :

(i) *Inner anterior bundle.*—It is a thick, mesially placed muscle originating from the frons and attached on anterior end of the pharyngeal tube (Fig. 21, 23, 25 ; LPDI).

(ii) *Outer posterior bundle.*—It is thin and straight bundle of muscles running dorso-ventrally from the occiput and attached to the posterior end of the pharynx (Fig. 21, 23, 25 ; LPD_2).

SUMMARY

A detailed account of the head capsule and mouth parts with their musculature has been given. It has been pointed out that due to welding together of various sclerites, the sutures have become almost obliterated. Further it has been noted that the tentorium is completely absent ; the mandibular stylets bear distally, serrations and comb-like ridge on their inner surface and maxillary stylets have interlocking arrangement.

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KEY TO LETTERING OF FIGURES

A_1, A_2 Antennal apodemes at the base.
I A - First intrinsic adductor of labium.
II A - Second intrinsic adductor of labium.
AB - Abductor of labium.
ACL - Ante-clypeus.
AN - Antenna.
AS - Antennal suture.
B - Beak.
BR - Basal rim of antenna.
BS, BSC - Basal scape.
BU - Buccula.
BU_1 - Buccula (dotted outline).
C - Comb-like process.
CA - Cavity of the salivary syringe.
CB - Cibarium or sucking pump.
CD - Cibarial dilator muscle.
CR - Ventral groove of anteclypeus
CLC - Clypeal cleft.
CSD - Common salivary duct.
D - Diaphragm.
DE - Depressor of pedicel.
E - Compound eye.

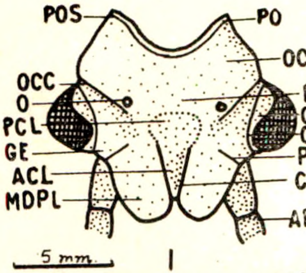
ED - Ejaculatory duct.
EP - Epipharynx.
EX - Extensor of labium.
F - Frons.
FG - Frontal ganglion.
FL_1, FL_2, FL_3 - Flegallar segments 1, 2, 3.
FX - Flexor of labium.
G - Place of attachment of mandibular lever with cranium.
GE - Gena.
GU - Gula.
H - Triangular ridges on maxillary stylet.
J - Interlocking arrangement of maxillary stylet.
K_1, K_2 - Process on mandibular stylet base.
LB_1,LB_2,LB_3,LB_4 - Labial segments I, 2, 3, 4.
LE - Levator of pedicel.
LG - Labial groove.
LR - Labrum.
LR_1 - Labrum broken at the base.
LRG - Ventral groove of labrum
LO - Lorum.
M - Membrane.
MDG - Mandibular gland.
MDL - Mandibular lever.
MDPL - Mandibular plate.
MDS - Mandibular stylet.
MG - Mandibulo-maxillary groove.
MP, MP_1, MP_2 - Protractor muscle of mandibular stylet.
MPD - Median process of hypopharynx.
MXPL - Maxillary plate.
MXPR - Maxillary process.
MXT - Maxillary stylet.
N - Median ridge of maxillary stylet.
NS - Tooth-like serrations(inner).
O - Ocellus.
OC - Occiput.
OCC - Occipital suture.
OCS - Ocular suture.
OCX - Occipital ridge.
OL - Occipital condyle.
P - Piston.
PD - Pedicel.
PD_1 - Pedicel (broken).
PCL - Post-clypeus.

PH - Pharynx.
PR - Piston rod.
R_1, R_2 - Retractors of mandibles
RN_1, RN_2 - Extrinsic antennal muscles

EXPLANATION OF FIGURES

Fig. 1. Dorsal view of the head showing the clypeus, frons and occiput.
Fig. 2. Antero-lateral aspect of the head capsule showing the attachment of the labium.
Fig. 3. Ventral view of the head capsule showing the relationship of bucculae to the base of the labium.
Fig. 4. The antenna.
Fig. 5. Basal portion of the antenna showing the antennal apodemes.
Fig. 6. The labium.
Fig. 7. Lateral view of the head capsule showing the complete labium.
Fig. 8. Ventral view of the ante-clypeus and the labrum showing the path of a stylet.
Fig. 9. Lateral view of the ante-clypeus and the labrum.
Fig. 10. Terminal inner margin of the maxillary-stylet showing the interlocking triangular ridges.
Fig. 11. Base of the maxillary-stylet showing the maxillary lever.
Fig. 12. Magnified view of the portion of the maxillary-stylet showing the inter-locking arrangement.
Fig. 13. Magnified view of the terminal end of the maxillary-stylet.
Fig. 14. Base of the mandibular-stylet with its musculature and mandibular gland.
Fig. 15. Magnified view of the terminal end of the mandibular stylet.
Fig. 16. Lateral view of the head with the interior exposed to show the extrinsic muscles of the antenna.
Fig. 17. Section of the scape of antenna showing the musculature.
Fig. 18. Lateral view of the head capsule with the interior exposed to show the mandibular stylet.
Fig. 19. The dorsal view of the mandibular-stylet showing the attachment of the muscles.
Fig. 20. Lateral view of the head capsule to show the attachment of the maxillary muscles and the position of the maxillary lever.
Fig. 21. Interior of the head capsule to show the muscles of the pharynx.
Fig. 22 & 24. Musculature of the labium.
Fig. 23. Muscles of the pharynx.
Fig. 25. Interior of the head capsule to show the arrangement of the wings of the hypopharynx.
Fig. 26. The hypopharynx and the sucking-pump.
Fig. 27. Lateral view of the salivary syringe along with its muscles.
Fig. 28. The salivary syringe.
Fig. 29. Hypopharynx.

PLATE I



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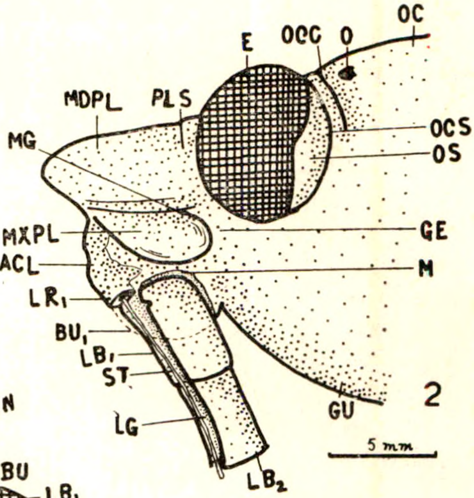

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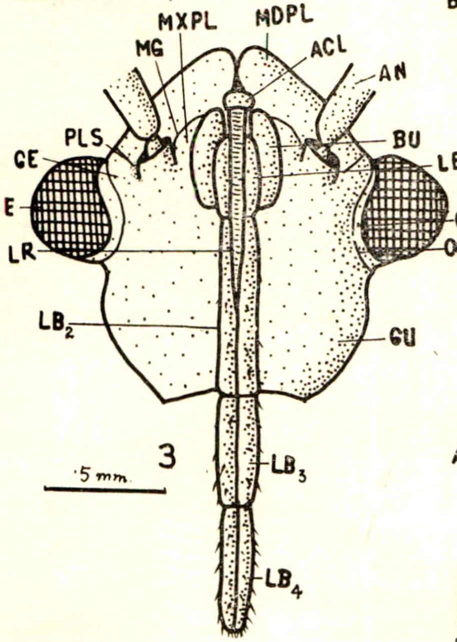

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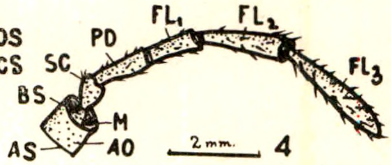

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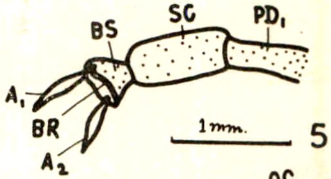

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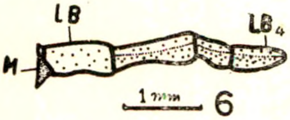

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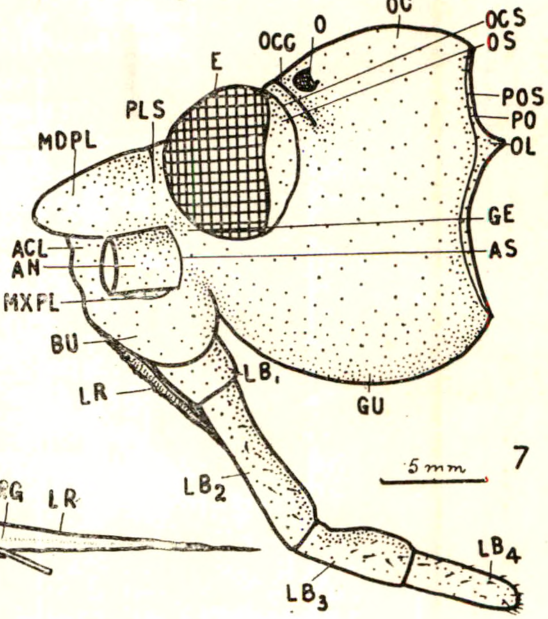

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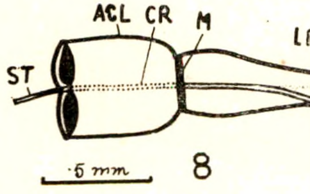

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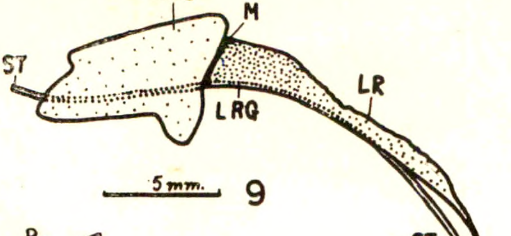

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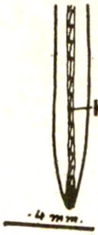

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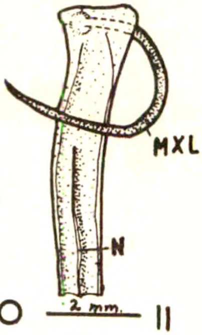

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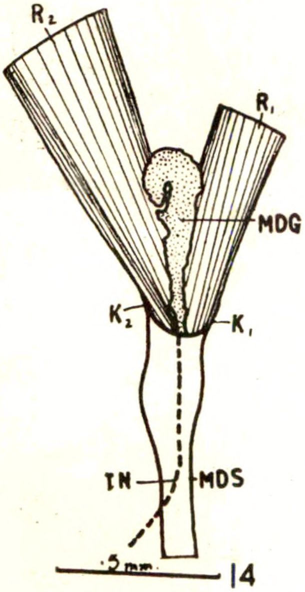

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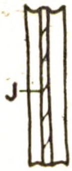

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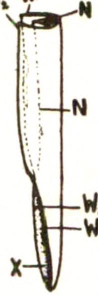

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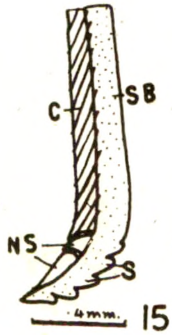

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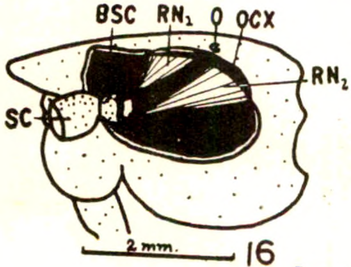

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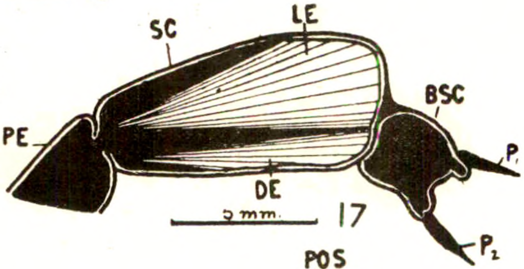

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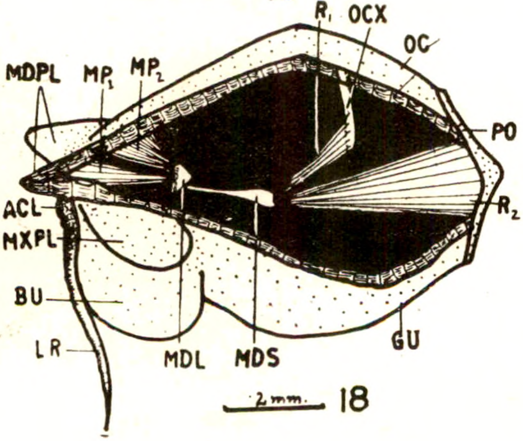

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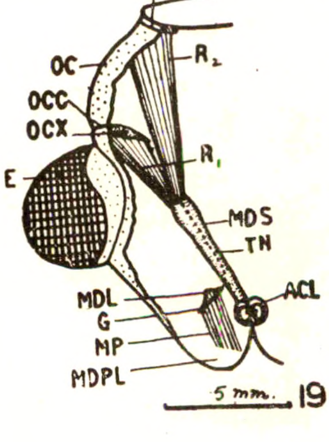

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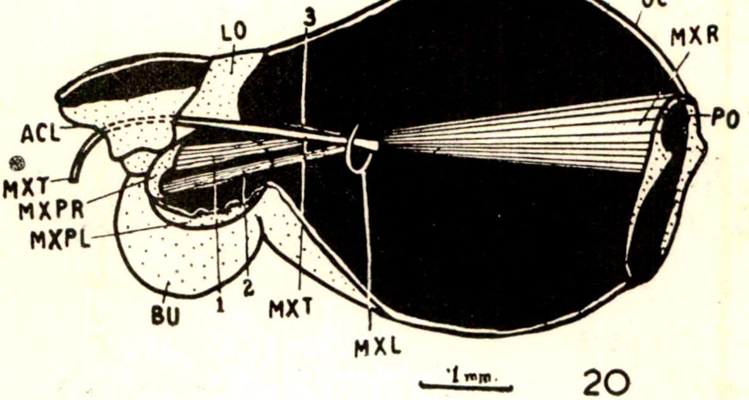

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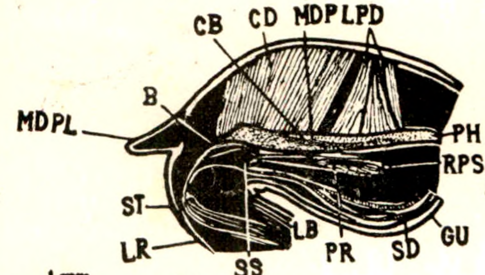

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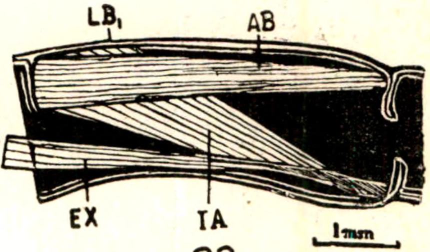

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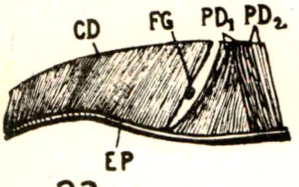

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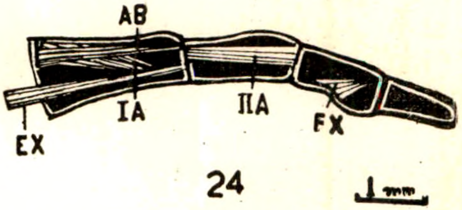

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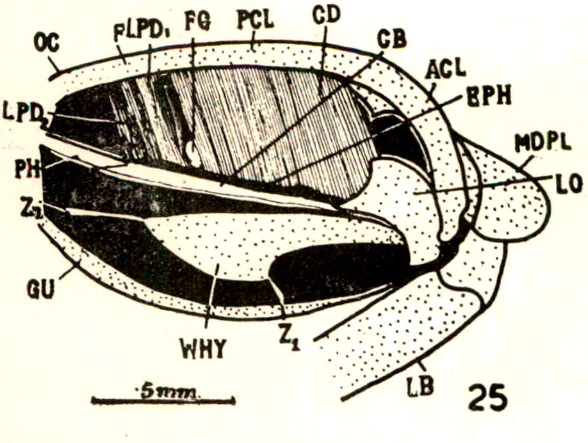

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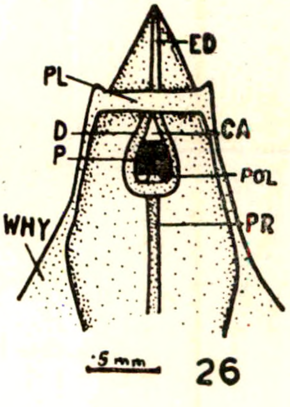

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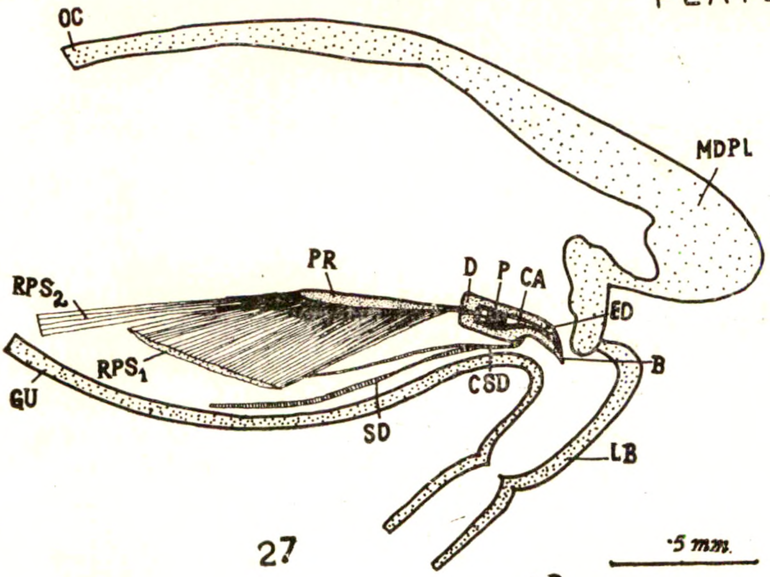
PLATE IV



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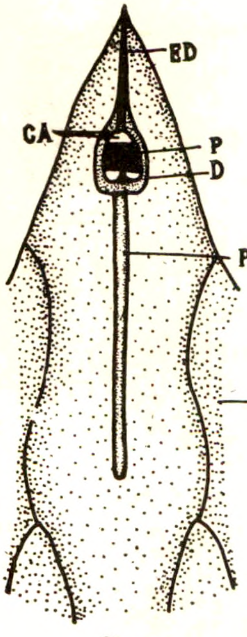

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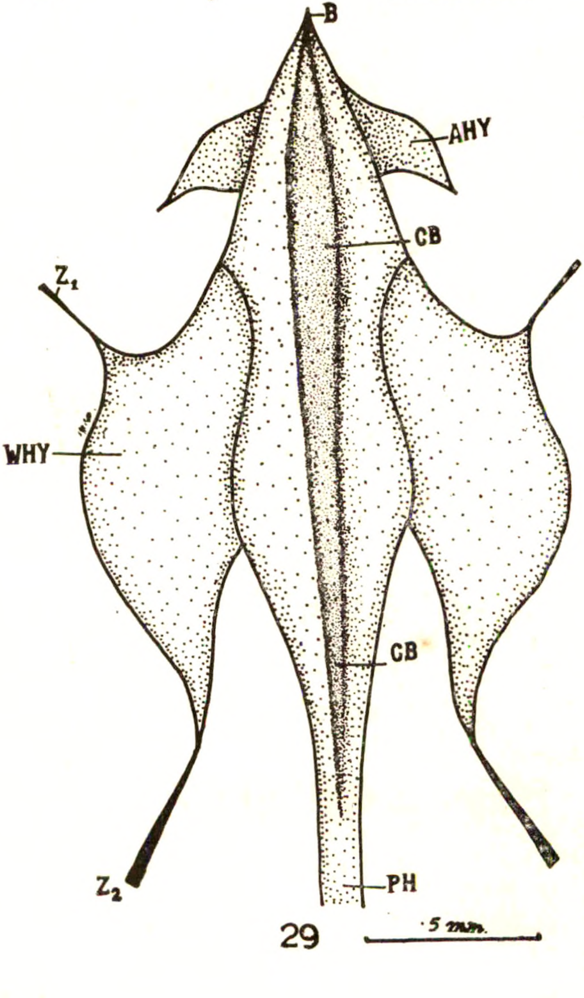

29

ENTOMOLOGICAL SURVEY OF HIMALAYA*

PART XXX—ON SOME CHRYSOMELIDAE (COLEOPTERA) FROM THE NORTH-WEST (PUNJAB) HIMALAYA

By S. P. SHUKLA, M.SC., *113/105, Swarup Nagar, Kanpur.*

In this paper I summarize the results of my studies on the Chrysomelidae, collected by Prof. M. S. Mani's Three Entomological Expeditions to the North-West Himalaya, organized by him from the School of Entomology, St. John's College, Agra, during the years 1954-56. Through the kindness of the Director, Zoological Survey of India, Calcutta, it has also been possible for me to examine the Chrysomelid material collected by Dr. A. P. Kapur, Zoological Survey of India, who was attached by the Government of India to Prof. Mani's Second Expedition in 1955.

Of the twenty-six species dealt with here, eleven are new to science and five are being recorded for the first time from the region of the North-West Himalaya. Though most of the specimens were collected at relatively low elevations within the taiga zone, a few specimens were taken above the timber line at elevations of about 4000 metres above mean sea level. The collections, including the type specimens of the new forms, have been desposited by Prof. Mani in the Zoological Survey of India.

I take this opportunity of expressing my thanks to Prof. Mani for placing this interesting material at my disposal for study and for occasional guidance. I am indebted to Dr. Santokh Singh, St. John's College, Agra for valuable suggestions and help in the preparation of this paper.

Subfamily CLYPTINAE

Coptocephala dubia Baly

1878. *Coptocephala dubia,* Baly, *Cistula Ent.*, 2:370

I have before me 1 example : Kulu Valley, Katrain, 1670 metres above mean sea level, Coll. A. P. Kapur, 24-vi-1955 ; 1 example, Manali, 1830 metres above sea level, Coll. A. P. Kapur, 26-vi-1955.

The following notes should serve to supplement the description of the species by Baly (*loc. cit.*) :

Body elongate subcylindrical ; anterior half of head fulvous, posterior half blackish ; tips of mandibles black ; first two antennal segments light brown,

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*Part XXIX of this series appeared in the *Proc. National Acd. Sci.*, Allahabad, 28 (B) (4) : 303-314 (1958). M. S. Mani.

the rest of the antennae black above and light brown below ; pronotum entirely brown ; scutellum black, sometimes apically brown ; elytra with large basal spot touching the base only near the scutellum but not touching the suture and laterally extending almost to callus ; another post-median subapical transverse band just missing the sutural and lateral margins ; the basal spot too is so large that when the elytra are closed together they appear as alternate bands of black and brown ; underside, prosternum brown ; mesosternum and metasternum black ; abdominal sternites blackish.

Head sparsely pubescent, wider than long ; with the labrum very short, its front margin concave, sparsely pubescent ; clypeus swollen, very minutely and sparsely punctate, otherwise smooth and glabrous ; separated from the frons by a rather deep V-shaped groove, foveolated in the middle of intra-ocular space ; the area between this fovea and the eyes rather rugose, with scattered setae ; vertex sightly flattened, smooth, indistinctly separated from the frons; antennae short, hardly extending back to the base of pronotum; first segment stout, globose ; second segment smaller ; third segment more slender and nearly equal to the fourth segment ; the fourth segment slightly stouter ; fifth and the following segments nearly equal in length, but somewhat stouter. Eye entire. Pronotum twice as wide as long, strongly convex, with the sides distinctly margined and narrowing anteriorly ; front margin very distinctly concave in the middle ; hind margin sinuate, the median lobe of which is truncate, this truncated part is also strongly depressed; front angles strongly rounded; hind angle somewhat projecting upward; the surface microscopically punctate, otherwise smooth and shiny. Scutellum broadly triangular, convex, with the apex rounded, impunctate. Elytra with base as wide as pronotum ; basal margin elevated ; callus indistinct ; elytral surface obscurely depressed along the suture behind the scutellum ; surface of elytra finely and sparsely punctate ; interstices very distinctly punctate ; the punctures tending to from paired rows. Underside pubescent ; prosternum invisible between the anterior coxae ; mesosternum very narrow. The last abdominal sternite in female with a median fovea.

Distribution.—This species was recorded from Kashmir by Paiva.[1] It appears to be widely distributed on the outer ranges in the region of the North-West Himalaya.

Subfamily CRYPTOCEPHALINAE

Cryptocephala sannio Redt.

1848. *Cryptocephalus sannio*, Redtenbach. in Hugel's Kaschmir, 4:561.

1908. *Crytocephalus sannio*, Jacoby, Fauna British India, Coleoptera: Chrysomelidae : 251-252, fig. 96.

I have before me 1 example : Manali, 1980 metres above mean sea level, Coll. Santokh Singh, 25-vi-1955.

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[1] Paiva. 1909. *Rec. Indian Mus.*, 2:406.

The specimen differs from Jacoby's description (*loc.cit.*) in the following respects:

Head not black but light brown, with two lateral, triangular spots, one on each side, touching the emargination of the eyes, the apex of these spots facing each other in the middle of the interocular space ; a median triangular spot on vertex, the apex of which faces the interocular space. Antennae (lost in Jacoby's material) with the first four segments light brown, fifth segment black only apically, the rest of antennae black. Pronotum with the spots not extending to the front margin, but contiguouswith the hind margin by an

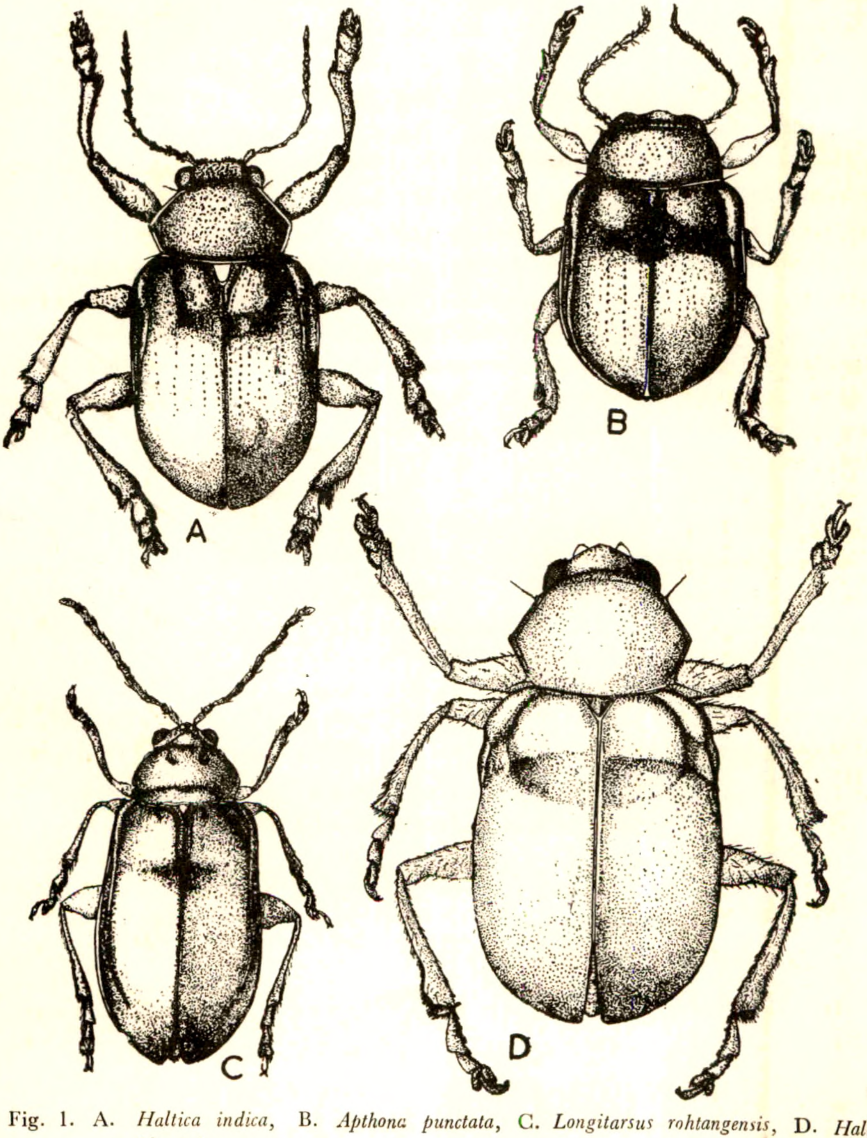

Fig. 1. A. *Haltica indica*, B. *Apthona punctata*, C. *Longitarsus rohtangensis*, D. *Haltica himensis*.

oblique black marking. Elytral spots separate from each other ; the two post-medians of each side not quite touching the suture as described by Jacoby. Underside black, legs and lateral margin of abdominal sternites brown. Pronotum with the hind margin lobed in the middle. Scutellum heart-shaped, truncate apically, with a basal median and an apical depression, longer than broad ; surface impunctate, smooth. Elytra slightly raised just behind the scutellum at suture ; interstices granular, aciculate when seen under high magnification. Underside finely and sparesely punctate; last abdominal sternite with a median fovea.

Distribution.—Throughout the outer ranges of the region of the North-West Himalaya.

Subfamily EUMALPINAE

Cleorina metallica, sp. nov.

Fig. 3 B, 4 H-I.

Body broadly ovate, convex. Labrum brown ; first four antennal segments fulvous, rest of antennae black ; head and pronotum metallic-green or blue ; scutellum bluish-green ; elytra metallic-green or blue ; underside and legs black, with metallic shimmer ; tibiae and tarsi somewhat brownish.

Head retracted under the front margin of pronotum as far as eyes ; labrum short, as wide as long, granular except for a few punctures anteriorly ; clypeus quadrate, not distinctly separated from frons, flat, very closely and strongly punctate, anteriorly triangularly emarginate, sides slightly ridged, two lateral faint V-shaped grooves extend backward from the middle over the upper margin of eyes ; frons broad, strongly but not as densely punctate as clypeus, with a distinct, short, longitudinal groove in the middle ; the interstices granular ; eyes entire. Antennae filiform, long, slender, reaching back to the middle of elytra ; first segment the stoutest, swollen, curved ; second antennal segment subcylindrical, shortest ; third segment longer than the fourth ; fifth and the following segments subequal, thickened. Pronotum wider than long, narrowed in front ; anterior margin slightly concave, posterior margin slightly lobed in the middle ; the sides not visible when viewed from above due to the strong convexity of pronotum ; surface of pronotum strongly and closely punctate ; the transverse groove extending along the anterior margin very distinct. Scutellum subquadrate, somewhat depressed ; sparsely but distinctly punctate. Elytra longer than wide parallel-sided ; rounded apically; base wider than pronotum ; callus and intrahumeral groove distinct ; callus extends behind as a short carina along the length of elytra, limiting a longitudinal groove below itself ; this ridge not sharp in the male ; elytral surface punctate-striate ; the punctures smaller than on pronotum ; at the sides and at base the punctures stronger and irregularly scattered; apically finer and smaller ; the interstices with a minute and scattered punctation.

Underside pubescent ; prosternum very wide, rather rugosely punctate; pro-episternum convex at front margin, rugosely punctate; metasternum feebly, finely and sparsely pubescent-punctate ; femora unarmed ; middle and hind tibiae emarginate apically ; in female the last abdominal sternite broadly emarginate, pygidium broadly rounded ; in the male the sternite entire, pygidium slightly narrowed.

Aedeagus with the median lobe tubular, strongly sclerotized in the front half ; strongly bent in the middle ; dorsal side rather swollen, forming in front the upper edge of the median orifice ; ventral side produced in front beyond the median orifice into a condyle-like structure ; basal part of the tegmen dorso-venrally fllattened ; internal sac with a long ejaculatory duct. Spermatheca sickle-shaped, with the two arms equal ; distal end acute ; proximal end broad where the duct opens on the outer side.

Length 4.2 mm, width 2.5 mm.

Holotype one female, *allotype* one male; *paratypes*, Manali, 1830 metres above mean sea level, Coll. A.P. Kapur, 25-vi-1955.

This species comes close to *C. jacobyi* Duviv[2] but differs in the punctation of pronotum being strong and close but not rugose ; in the scutellum being distinctly punctate and not smooth. The very strong lateral elytral costs more pronounced in female ; in *C. jacobyi*, however, though the costa is present it is not so strong and is actually indistinct in the female.

Eubrachys indica Baly

1877. *Eubrachys indica*, Baly, *J. Linn. Soc.*, 14:249.
1908. *Eubrachys indica*, Jacoby, Fauna British India, Coleoptera: Chrysomelidae 1:433.

I have before me 1 example : Manali, 1980 metres above mean sea level, Coll. V. K. Gupta, 23-vi-1955.

The specimen should be referred to the blue variety described by Baly (*loc. cit.*).

The following notes supplement the description by Jacoby (*loc. cit.*):

Labrum and mouthparts, the six basal antennal segments, bases of femora and tibiae brown ; rest of body entirely deep metallic-blue ; five terminal antennal segments black.

Clypeus not distinctly separated from frons, rugosely punctate, the punctures with scale-like setae ; antenae with the second segment longest, clavate ; third segment equal to the fourth, more slender and about half the length of second; fifth and sixth segments nearly equal to the preceding, but thicker; the following segments subequal and abruptly thickened. Pronotum with punctures as large as on head and very close to each other to form rugosities, but not fine as mentioned in Jacoby's description (*loc. cit.*). Elytra with the interstices rough, the punctures at the sides stronger Femora with a single acute tooth before the middle. Prosternum and mesosternum broader than long.

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[2] Duviv. 1892. *Ann. Soc .ent. Belgique*, 36:414.

Distribution.—Widely distributed on the outer ranges of the region of the North-West Himalaya from Kashmir and extending east of the R. Sutlej to Garhwal Himalaya (Simla) and extreme west of Kumaon (Mussurie.)

Nodostoma manaliensis, sp. nov.

Fig. 3 A, 4 J.

Body oblong-ovate, convex. Labrum light-brown, palpi and first four antennal segments reddish-brown ; pronotum and scutellum reddish-brown ; elytra cupreous ; underside including legs reddish-brown, with slight metallic gloss.

Head with the labrum short, broader than long ; anteriorly triangularly and deeply emarginate in the middle ; with one or two setigerous punctures

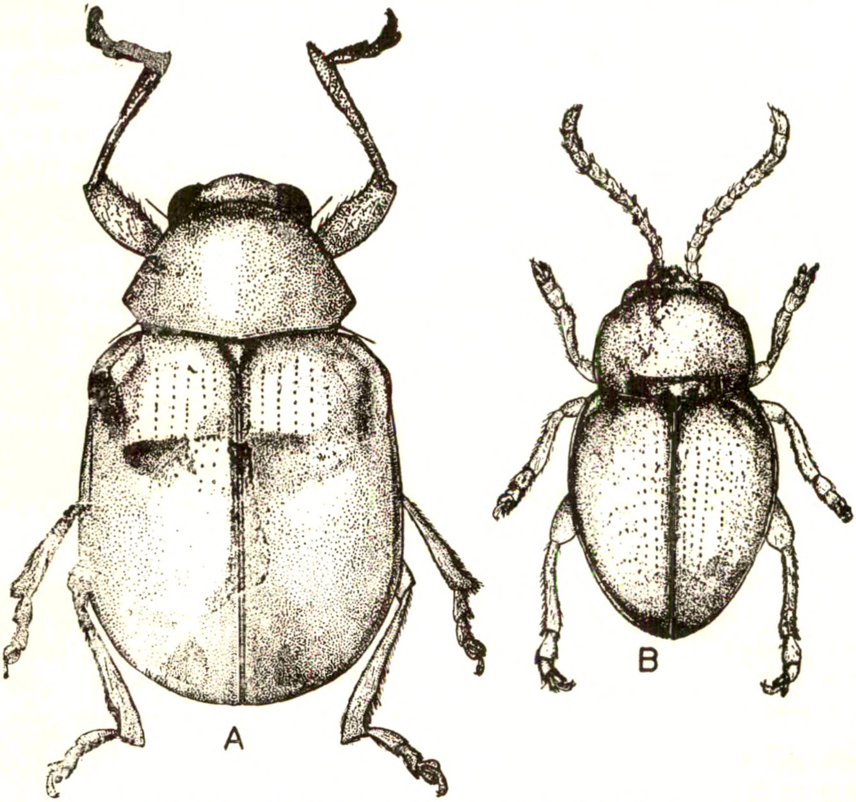

Fig. 2. A. *Nodostoma virendri*, B. *Podagarica alticus*.

in front; rest of the surface finely granular; clypeus not separated from frons, anterior margin deeply and triangularly emarginate, wedge-shaped, slightly depressed, strongly ridged laterally above the antennal bases; interocular space with a median-longitudinal deep groove, posteriorly foveolated ; the whole surface very deeply punctured ; vertex strongly convex, the punctures finer on vertex. Antennal bases separated by the entire width of head ; antennae slender, short, filiform, finely pubescent ; first segment stoutest, slightly curved ; second segment subclavate and curved ; third segment thinnest ; fourth segment stouter than third ; fifth and succeeding segments gradually thickened ; second segment equal in length to the third ; sixth and the succeeding segments subequal, but each smaller than the fourth. Eyes entire, slightly convex. Pronotum distinctly margined laterally; nearly one and a half times wider than long; distinctly angulated at sides just behind the middle ; from this point the sides narrowed both in front and behind ; anterior margin concave is the middle ; posterior margin weakly lobed in the middle ; anterior angles projecting and posterior angles distinctly tuberculate, each of the angles bears a setigerous pore at the tip ; deeply and closely punctate, the punctures as large as on vertex ;the narrow groove along the anterior and basal margins distinct, the former with the punctures similar to that of the disc but the latter with a row of finer punctures ; faintly depressed near each of the marginal angulations. Scutellum longer than wide ; the tongue-shaped apex very broadly rounded ; flat, smooth, impunctate. Elytra longer than broad; parallel-slided ; rounded apically ; callus and intra-humeral groove very prominent, the former with microscopic punctures and bounded on each side by punctate striation ; just behind callus on each side a distinct longitudinal groove, including lateral margin also within it, extends backward right up to the apex this groove bounded laterally by two short strong carinae just behind callus; an elongate strong costa extending right up to the apex of the elytra ; a short longitudinal depression behind the scutellum along the suture; the punctures are crowded and close together within this depression and also tend to be somewhat irregular; post-basal transverse depression distinct, strongly convex and punctate-striate, the punctures arranged in six distinct rows, but these rows are obliterated laterally and at base; apically the punctures become finer; interstices with finer, close and irregular punctures; a few of the interstice cos tate behind the middle.

Underside sparsely pubescent ; prosternum longer than wide, flat, coarsely and strongly punctured ; pro-episternum slightly concave at the front margins, flanks of pronotum strongly, deeply but sparsely punctate. Anterior femora at inner edge with a short median tooth ; hind femora with a similar tooth but nearer to the apex ; middle and hind tibiae emarginate at apex.

Aedeagus with the median lobe tubular, strongly sclerotized in the anterior half ; bent almost at right angle, at the point of union of the anterior sclerotized and posterior membranous halves; ventral side projects beyond the median orifice and narrows to a rather acute apex ; median foramen occupies the posterior half ; the dorsal wall arched, ending anteriorly over the median rectangular orifice, at the sides of the orifice two smaller longitudinal short strips extend as horns ; basal part of the tegmen bilobed, membranous ; two lobes joined together posteriorly.

Length 4.3 mm, width 2.3 mm. Males generally shorter than females.

In some examples pronotum is almost concolourous with the elytra.

Holotype one female, *allotype* one male, *paratypes* females and males : Manali, 1830 metres above mean sea level, 25-vi-1955, Coll. A. P. Kapur.

This species comes very close to *N. nobilitatum* Jac.[3] but differs in the brown colour of pronotum, antennae and underside. In *Nodostoma nobilitatum* Jac. the pronotum is metallic-green like elytra ; underside and antennae are blackish. The lateral elytral costae further differentiate the new species. The elytral interstices are also very distinctly and rather closely punctate.

Nodostoma manii, sp. nov.

Fig. 3D.

Body elongate-oblong in outline. Head brown, with a light matallic green shimmer near the eyes and clypeus ; first five antennal segments light shiny brown, the rest of antennae dark brown and opaque ; pronotum brown, with metallic-green reflections at base ; scutellum brown; elytra metallic-green; underside including legs dark brown and shiny.

Head with the labrum broader than long ; clypeus concave, strongly ridged laterally, front margin emarginate ; confluently punctate ; interocula space with a median longiudinal, very narrow groove ; punctures become smaller and well separated from each other toward vertex. Antennae slender, filiform, nearly half the length of body ; first segment long, stoutest, clavate ; second segment more slender but stouter apically than basally, nearly equal to the first in length ; third and fourth segments slender ; the third segment somewhat shorter than the fourth and the second; the fourth segment longest and one and a half times the length of the second ; segment ; fifth segment slightly shorter than the sixth segment ; the following segment subequal and flattened. Eyes entire. Pronotum nearly twice as wide as long, narrowing anteriroly ; the posterior margin slightly triangularly produced in the middle; the sides distinctly margined, angulate just after the middle; anterior angles with small tubercles; the surface convex, closely punctate; the punctures as large as on the elytra or head ; with the interstices granular a faint groove along the anterior margin. Scutellum quadrate ; truncate apically ; the surface with a few minute punctures . Elytra convex, slightly wider than pronotum at base ; callus prominent, impunctate, intrahumeral groove distinct, meeting behind the distinct transverse post-basal groove ; the area between the fourth and fifth rows of punctures grooved, punctato-striate at base ; the punctures become smaller apically ; interstice between fifth and sixth rows strongly costate at base only ; a strong costa extends from the inner side of the callus along the side of elytra to nearly the apex ; the callus itself continues below as another costa, parallel to the former but less pronounced; the punctures between the strong costa and the margin very close and irregular, large up to the middle of elytra then arranged in two definite rows; punctures nearabout callus irregular; the same is the case with the punctures in the post-basal depression but not close.

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[3] Jacoby. 1895. *Ann. Soc. ent. Belgique,* 39:289.

Underside with setigerous punctures strong but sparse ; meso-and metasterna strongly and sparesly punctate ; abdominal sternites with setigerous punctures ; at sides each sternite with a circular depression ; femora with small tooth near apex and pointed forward.

Length 4.1 mm, width 2. mm.

Holotype one example : Manali, 2600 metres above mean sea level, Coll. Santokh Singh, 25-vi-1956, Sta. No. 5.

This species comes close to *Nodostoma nobilitatum* Jac. (*loc. cit.*), but differs in the colour of pronotum, underside and in the elytral punctation.

Nodostoma virendri, sp. nov.

Fig. 2 A.

Body with head brown ; the first four antennl segments fulvous, rest of antennae gradually becoming darker ; pronotum piceous, slight brown shade near the anterior margin in the middle ; scutellum blackish-brown ; elytra black ; the rest of body including legs dark brown and shiny,

Head with the clypeus flat, slightly ridged at sides ; the anterior margin of clypeus slightly emarginate, the surface closely punctate ; not separated from frons, latter is globose and closely punctate. Antennae with the third and fourth segments equal and slender ; second segment smaller and swollen ; fifth and the following segments slightly flattened at the apices and gradually shortened. Eyes only very obscurely emarginate on the inner side. Pronotum more than twice as wide as long, anteriorly converging ; the posterior angles in the form of small tubercles ; lateral margins distinct, slightly deflexed strongly angulate near the base ; surface convex, very closely and strongly punctate, the punctures stronger at the sides ; along the anterior margin a distinct row of smaller punctures within a shallow groove. Scutellum subquadrate, surface with a few punctures. Elytra with callus very prominent, depression below rounded and distinct ; surface strongly convex, punctatestriate, the punctures smaller than on pronotum, finer apically; scutellar on short and distinct ; interstices irregularly punctured only at base, puncture within the post-basal depression lose their regularity ; laterally below callus at margins a rather small longitudinal groove ; the row before the marginal one and the third row meet at apex to form a distinct depression.

Underside with a small tooth on the middle of femora; flanks of pronotum, mesosternum and metasternum strongly punctured.

Length 4.4 mm, width 3.6 mm.

Holotype 1 example : Katrain: Kulu Valley; 1370 metres above mean sea level, Coll. V. K. Gupta, 37-vi-1956.

Subfamily CHRYSOMELINAE

Chrysolina bella (Jacoby)

1890. *Chrysomela bella*, Jacoby, *Entomologist*, 23:253.
1926. *Chrysolina bella*, Maulik, Fauna British India, Coleoptera : Chrysomelidae, Chrysomelinae p. 39.

I have before me one example : Chamba (Upper Ravi Valley), North Slope of Dhauladhar Range, 305. metres above mean sea level, Coll. Santokh Singh, 5-7. vi. 1954.

Distribution.—Common on the Dhauladhar Range throughout the North-West Himalaya, also extending to the Kashmir Valley north of the Pir Panjal Range and to Peshawar in Pakistan.

Chrysomela chlorina Maulik

1926. *Chrysomela chlorina*, Fauna British India, Coleoptera : Chrysomelidae ; Chrysomelinae & Halticinae, p. 69,

I have before me 1 example : Manali, 1830 metres above mean sea level, Coll. A. P. Kapur, 25-vi-1955 ; 2 examples, Manali, 2000 metres above mean sea level, Sta. No. 3, Coll. Santokh Singh, 24-vi-1955.

The large paired spots on the side of the median longitudinal line on pronotum fused to form a transverse band ; scutellum with a distinct median depression.

Distribution.—On the outer ranges of the Kumaon Himalaya (Almora, Ranikhet, Sunderdunga Valley); Upper Kulu Valley in the North-West Himalaya.

Plagiodera versicolora (Laich.)

1781. *Chrysomela versicolora*, Laicharting, *Verz. Trol Ins.*, 1:148.
1926. *Plagiodera versicolora*, Maulik, Fauna British India, Coleoptera : Chrysomelidae, Chrysomelinae & Halticinae, p. 61.

I have before me 1 example : Sissu (Lahaul Valley), Southern Slopes of the Great Himalaya , 3200 metres above mean sea level, Coll. A. P. Kapur, 10-vi-1955.

Thorax and head darker than elytra ; five basal antennal segments rather blackish or very dark brown, but never yellow as described in the literature (*loc. cit.*) ; scutellum with a distinct depression.

Distribution.—Widely distributed on the lower and outer ranges of the region of the North-West Himalaya and extending to the North-West Frontier Province (Pakistan) and extending east into the western reaches of the Kumaon Himalaya.

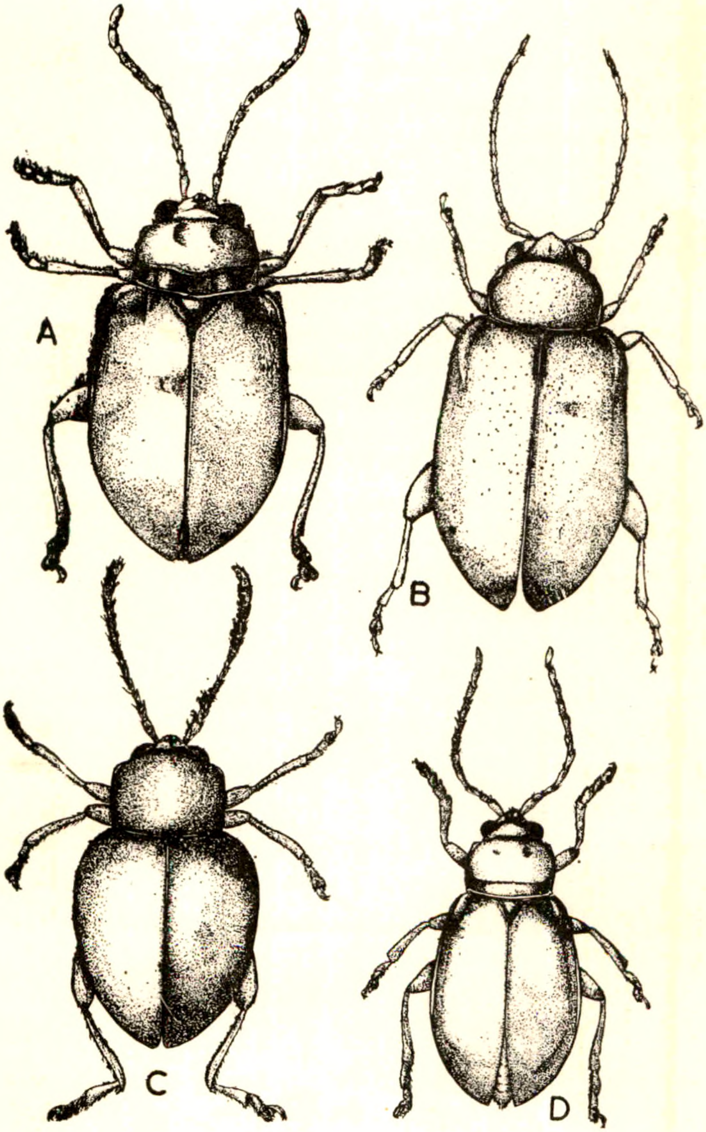

Fig. 3. A. *Nodostoma manaliensis*, B. *Cleorina metallica*, C. *Cleorina bicosta*, D. *Nodostoma manii.*

Subfamily HALTICINAE

Apthona punctata, sp. nov.

Fig. 1 B.

Body flat, narrow, elongate, parllel-sided ; metallic-blue ; labrum black ; first antennal segment fulvous apically ; second and third antennal segments flavous ; rest of antennae black ; underside bluish-black ; tibiae and tarsi blackish-brown.

Head with labrum short, slightly wider than long ; with very minute and fine punctation ; clypeus with the anterior a margin swollen and with a median interantennal carina distinctly swollen and granular ; frontal tubercles vertical, separated from the interantennal carina by short oblique groove and from each other by a very short foveolated space ; elevated and smooth ; vertex pentagonal, anteriorly very acute ; separated from the frons by an oblique narrow groove extending on each side from between the frontal tubercles ; backward extending behind eyes. Eyes separated from the frontal tubercles by a short deep longitudinal groove ; vertex with a few distinct punctures and distinctly transversely wrinkled or aciculate. Antennae long, slender, reaching back almost to the middle of elytra; first antennal segment longest, stoutest; second segment stout but shorter than the third ; the third antennal segment more slender but equal to the fourth ; the foruth and the succeeding antennal segments equal and becoming gradually widened. Eyes entire, prominent. Pronotum approximately one and a half times wider than long ; the sides almost parallel, with distinct margins ; anterior margin slightly concave ; posterior margin straight ; the surface of pronotum convex , very finely and sparsely punctate ; the punctures more crowded together in the posterior half of pronotum. Scutellum broadly triangular, with the apex rounded and granular. Elytra wider at base than the pronotum ; laterally depressed behind the base, then again widened behind the middle and finally narrowed at apex ; callus indistinct, interhumeral groove absent ; finely and sparsely punctate ; the punctures on the elytral syurface with a distinct tendency to form rows : the punctures become finer towards apex ; the appex of elytra acute ; apically with the margins fringed with short setae.

Underside scantily pubescent, smooth ; prosternum narrow, shiny, not arched ; mesosternum broad.

Length 1.8 mm, width 1.0 mm.

Holotype one example, *paratypes* two examples : Kote Upper Beas Valley, 2440 metres above mean sea level, Coll. A. P. Kapur, 20-vi-1955.

This species comes close to *A. andrewesi* Jac[4]. and *A. indica* Jac.[5] but differs in the punctate pronotum, antennal colour and legs.

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[4] Jacoby. 1896. *Ann. Soc. ent Belgique,* 40 : 256.

[5] Jacoby. 1900. *Mem. Soc. ent. Belgique,* 7:120.

Chaetocnema rahlensis, sp. nov.

Body ovate, strongly convex ; light bronze-coloured, with cupreous reflections ; labrum dark brown ; first two antennal segments shiny light brown, the rest of the antennae missing in the single specimen before me ; femora shiny bronze-coloured ; tibiae and tarsi lighter brown.

Head with the labrum strongly transverse, very much broader than long, angulated at the sides, anteriorly narrowed, front margin straight, laterally ridged ; clypeus anteriorly deeply and triangularly emarginated ; just behind anterior margin strongly and deeply punctate, setose ; frontal tubercles and interantennal carina absent ; from the middle of the interocular space two oblique, deep narrow grooves extend up to orbital border and bounded by an acute carina along the length of groove near the middle of the interocular space ; vertex with fine and sparse punctures unlike the strongly punctured interocular space in front. Antennae incomplete in the single specimen. Eyes entire. Pronotum nearly as wide as long ; the sides gently rounded, narrowing anteriorly, strongly convex ; lateral margins invisible when viewed from above ; rather sparsely punctate ; the punctures as large as on the vertex ; under higher mangification a smooth impunctate narrow longitudinal line along the middle of the disc ; interstices highly granular, without depression on the disc. Scutellum short ; very broad ; apex acute ; impunctate. Elytral base as wide as pronotum ; callus distinct but intrahumeral groove absent ; very slightly depressed longitudinally behind the scutellum along the suture ; punctate-striate in eleven distinct rows, including a short scutellar and an extreme marginal row ; the rows tend to form pairs ; in the depression behind the scutellum along the suture the punctures irregular due to the presence of a few extra puncutures in addition to those of the scutellar row ; interstices granular, at the sides a few of them costate ; punctures similar to the apex. Wings absent.

Underside with the gena rugosely punctate and pubescent ; flanks of the pronotum with a few punctures at anterior and posterior margins ; otherwise smooth and shiny; prosternum rugosely punctate ; the meso- and metasterna punctate but not so deeply and closely.

Length 2.4 mm, width 1.2 mm.

Holotype 1 example : Rahla (Upper Beas Valley), 2700 metres above mean sea level, under stones, Coll. A. P. Kapur, 25-v-1955.

This species is distinguished from the other known species from India in the total absence of wings. It also differs rom *C. cognata* Baly[6] in not having the punctures so close; the elytral punctures also differ. The absence of the wrinkles on the elytra near the scutellum would separate the species from *C. alticola* Maulik.[7]

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[6] Baly. *Trans, ent. Soo. London,* 1877, p. 168.

[7] Maulik. Fauna British India, Coleoptera: Chrysomelinae-Halticinae, p. 217 (1926).

Haltica bicosta. sp. nov.

Fig. 3 C, 4 A.

Body flat, elongate ; posteriorly nearly parallel sided ; bright metal-licblue, bluish-green or blue-black: underside black, with bluish gloss at places.

Head with the labrum short, as wide as long ; with the punctures on the labrum in the mid-transverse line, anterior margin concave in the middle; clypeus with the anterior margin strongly swollen with small pubescent punctures, posteriorly carinate and swollen; at the sides of the carina excavated, the excavations smooth; frontal tubercles almost vertical, very slightly elevated, flat, smooth and shiny, separated from each other by a short narrow groove face separated from the neck by a very faint transcrvse groove behind frontal tubercles ; this groove is foveolate, with a few punctures at the sides near the inner upper margin of eyes; vertex smooth. Antennae about half the length of body; first antennal segment longest and stoutest, clavate; the second segment smallest; third segment about twice the second; fourth segment appreciably longer than the third: the fourth and fifth segments equal; sixth and the following segments shorter than the fifth and slightly thickened. Pronotum nearly as wide as long; the sides in front rounded; hind margin sinuate; anterior angles bituberculate with seta on the lower tubercles ; hind angles triangular; slightly convex, rather closely and distinctly irregularly punctate; basal sulcus straight, narrow, broadly deepened at the posterior angles; behind the sulcus the area is flat, with two circular depressions in the middle and anterior to this it is convex ; behind the anterior margin in the middle are two oblique distinct depressions, extending toward the sides from the middle. Scutellum triangular, granular, shiny, with the apex very broadly rounded. Elytra with the callus and intrahumeral groove distinct; longitudinal depression along the suture behind the scutellum very distinct ; finely and very closely punctate ; the surface scaly ; interstices minutely punctate ; when viewed from an angle a few smooth striae from base to the apex; elytra at apex abruptly narrowed to an acute point which is slightly depressed ; just behind the callus a longitudinal depression extending up to the middle of elytra ; callus extends behind as a very strong costa to a little beyond the middle of the elytra ; the the area between the costa and the lateral margin again grooved. Underside pubescent ; prosternum narrow. Last abdominal sternite in male lobed and flattened in the middle. The males are somewhat smaller than females.

Aedeagus posteriorly parallel-sided ; widened from the middle apically; drosally grooved in the anterior half ; drosal wall ends as a circular edge over the median orifice ; the lateral sclerotized bands longer , narrow ; the middle clavate ; the lateral sides with many wrinkles, more numerous than in other Indian species ; ventral wall extending beyond the orifice and narrowed to a broad, blunt median tip anteriorly ; ventrally with a median and two lateral deeper grooves anteriorly.

Holotype one female and *allotype* one male; *paratypes* several males and females: Manali, 1830 metres above mean sea level, Coll. A. P. Kapur. 23-vi-1955.

Haltica himensis sp. nov.

Fig. 1 D, 4 B.

Body oblong-ovate ; general body colour metallic-blue, blue-black, greenish-blue or violaceous-blue ; antennae black with metallic gloss ; first antennal segment at base and apex slightly shiny brown ; scutellum black ; underside black, with metallic gloss.

Head with labrum wider than long, granular, with a row of distinct punctures along the posterior edge ; front margin slightly emarginate in the middle ; clypeus with the front margin swollen and almost straight ; incrassate, interantennal carina produced posteriorly; at the sides of this carina surface excavated, without any wrinkles or punctures, but very finely granular ; frontal tubercles obtriangular, oblique, slightly convex, separated by a short longitudinal deep groove, very minutely punctate ; vertex separated by a very distinct transverse groove just behind the tubercles, smooth. Eyes entire. Antennae long, reaching back to about the middle of elytra ; first antennal segment stoutest, subclavate ; second antennal segment shortest ; third antennal segment slender and shorter than the fourth ; the fourth antennal segment nearly twice the second ; fifth antennal segment and the succeeding segments slightly thickened, but shorter. Pronotum nearly one and a half times wider than long ; the sides rounded in front ; from the middle to base almost parallel-sided; posterior margin sinuate and lobed in the middle ; anterior angles thickened ; posterior angles broadly acute; very disctinctly but minutely punctate, the punctation variable, in some specimens very close but in others fainter; at the anterior angles with the usual larger and distinct punctures ; basal sulcus distinct but narrow and shallow, depressed at the hind angles; anteriorly just behind the anterior margin large depressions in the middle. Scutellum triangular, much wider than long, apex rounded ; with minute punctation Elytra somewhat convex, callus prominent ; with distinct intrahumeral groove; behind the scutellum along the suture as usual with the species of the genus a somewhat distinct groove ; elytral surface closely punctate, the punctures irregularly scattered ; but the punctures are fine ; posteriorly the punctation becomes finer ; the interstices with very minute punctures ; when viewed from an angle there are a few smooth ribs on the surface of elytra ; the elytral punctation is also variable like the pronotal punctation and is sometimes sparse.

Underside rough and very scantily pubescent. Aedeagus with the median lobe slightly curved or arched; dorsal slightly grooved in front and ending as a sclerotized flap over the median orifice, with two lateral narrow sclerotized strips ; lateral sides almost smooth, convex, sloping in the frontal half ; ventral side with a median groove all along its length ; anteriorly with two smaller side grooves ; anteriorly this side projects beyond the median orifice to a rather narrow apex, which is not very acute ; the dorsal side with the usual transverse striations.

Length 4.3 mm, width 2.15 mm.

Holotype one female, *allotype* one male, *paratypes* several female and male specimens : Rahla, 3.2 kilometres north from the Forest Gang Hut, from under stones, 3657 metres above mean sea level, Coll. A. P. Kapur, 30-v-1955.

There are also numerous specimens in the collections of the Zoological Survey of India from other parts of the Himalaya.

This species comes close to *H. caerulescens* Baly[8] but differs in the pronotal punctation, aedeagus, etc.

Haltica indica, sp. nov.

Fig. 1 A, 4 C.

Body ovate, convex ; bright metallic-blue, bluish-green, violaceous-black or shiny blue-black ; antennae, labrum and underside including legs black.

Head with the labrum much wider than long, front margin slightly emarginate in the middle ; a few setigerous punctures along a transverse median line ; interspaces granular ; clypeus wide , with the front margin straight, swollen, with one or two setigerous punctures laterally; a distinct interantennal carina swollen posteriorly ; on either side of the carina the surface excavated and strongly wrinkled ; frontal tubercles rounded, nearly contiguous and flat ; impunctate ; separated from vertex by a distinct transverse groove deepened at the sides near eyes ; vertex smooth, impunctate ; eyes entire. Antennae nearly half the length of body ; first antennal segment stoutest, subclavate ; second segment smallest ; third segment nearly twice or a little more than second; fourth segment equal to the third ; fifth segment nearly equal to the fourth ; the succeeding segments equal and sightly thickened. Pronotum wider than long ; the sides slghtly broadened behind, otherwise almost parallel-sided ; anterior angles thickened and produced anteriorly ; posterior angles with short denticles; posterior margins sinuate; the surface with very few indistinct sparse punctures visible only under high magnification, otherwise impunctate at first sight ; at the anterior angles the usual large punctures ; basal sulcus sinuate ; foveolate in the middle ; not reaching the sides ; just behind the anterior margin two distinct circular depressions in the middle. Scutellum triangular with rounded apex, granular, longitudinally depressed. Elytra convex; callus prominent ; intrahumeral groove distinct ; the longitudinal groove hind the scutellum slightly depressed ; the surface closely irregularly and rather strongly punctured; interspace smooth, indistinctly punctate and apically the punctures become sparse and finer.

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[8] Baly. 1874. *Trans. R.ent.Soc.London*, p. 196.

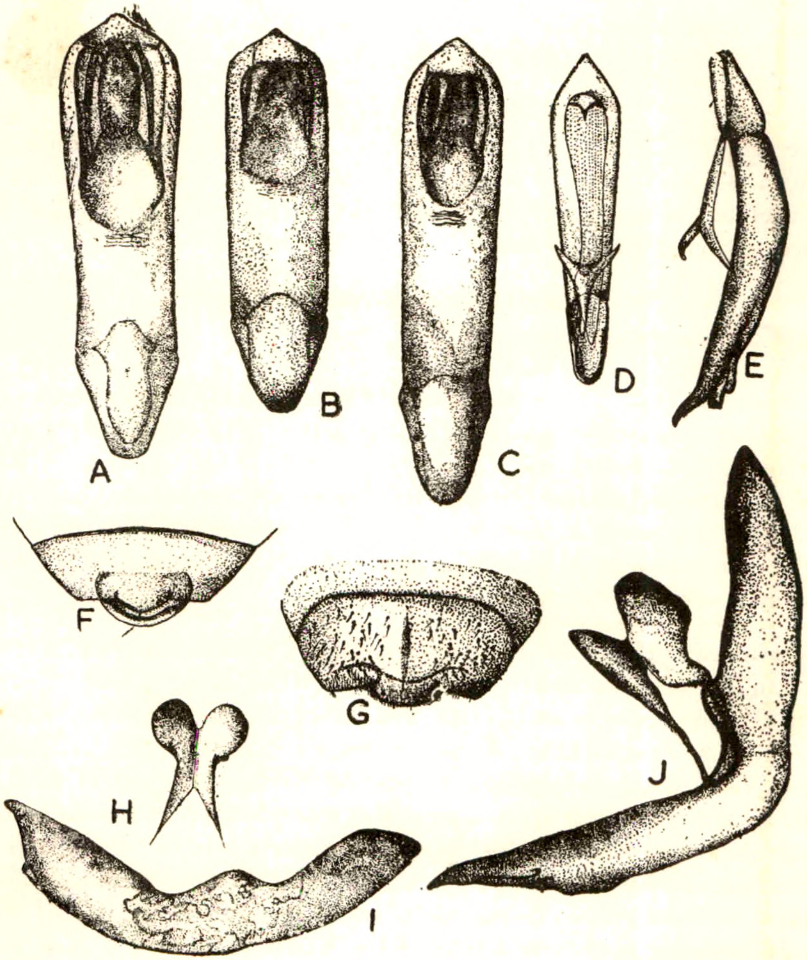

Fig. 4. Aedeagus of A. *Haitica bicosta*, B. *Haltica himensis*, C. *Haltica indica*, D. *Longitarsus rohtangensis*, E. *Podagarica alticus*, F-G. *Longitarsus rohtangensis*, H-I *Cleorina metallica*, J. *Nodostoma manaliensis*.

Underside pubescent as usual. Aedeagus with the median lobe tubular, sclerotized, drosal side convex, depressed in the anterior one-third, ending anteriorly over the median orifice as a broad flap, with two lateral sclerotized narrow strips ; lateral sides convex ; ventral side grooved very indistinctly ; anteriorly extending beyond the median orifice as a broad truncate apex ; lacking the transverse wrinkles on the lateral sides found in many other species of the genus ; the longitudinal sclerites of the internal sac very stout ; general shape of aedeagus resembles that of *Haltica foveicollis* Jac.

Length 5.7 mm, width 3.1 mm.

Holotype one female, *allotype* one male ; *paratypes* several female and male examples; Manali, 1830 metres above mean sea level, Coll. A. P. Kapur, 23-vi-1955.

I have also examined a large series of specimens of this species from nearly all over India in the collections of the Zoological Survey of India.

This species closely resembles *Haltica foveicollis* Jac.[9] but differs in the colour and absence of indistinct costa on the lateral side of elytra, especially in the female. The aedeagus differs in the apex being more pointed and not truncate. The species differs also from *H. cyanea* Weber[10] in the absence of lateral elytral longitudinal depression and the distinct elytral ribs on the surface, especially at the sides.

Longitarsus rohtangenis, sp. nov.

Fig. I C, 4 D, F G.

Body narrow, ovate, very small ; general body colour smoky-brown. with lighter shades here and there, head with bronze-sheen on vertex ; first three antennal segments lighter, the rest of the antennae gradually becoming darker ; pronotum smoky-brown ; elytra smoky-brown basally, but becoming paler apically ; basal lateral and sutural margins almost black or very dark brown ; posterior femora and tibiae dark brown ; hind tarsi lighter ; terminal abdominal sternite also paler.

Head with the general surface granular ; penultimate segment of the palpi swollen; labrum short, much broader than long, convex ; anterior margin slightly emarginate ; along the anterior margin a few setigerous punctures. Clypeus swollen along the anterior margin, with a median intertantennal carina, which is minutely punctate ; the surface on each side of this carina-slightly excavated, with setigerous punctures;frontal tubercles raised, indistinctly transverse, roundly triangular; separated from each other; vertex separated by a distinct groove just behind the frontal tubercles and passing obliquely ackward to the upper orbital margin. Antennae short, stout, slightly extend- g back beyound the elytral base; first antennal segment longest and stoutest; second segment thicker and longer than the third ; the third antennal segment equal to the fourth ; fifth segment longer than fourth; fifth also longer than the sixth segment ; the sixth segment and following equal and distinctly thickened. Pronotum one and a half times wider than long ; laterally gently rounded ; anterior margin almost straight ; posterior margin straight in the middle but rounded at angles ; anterior angles thickened and slightly produced posterior angles indistinct and rounded ; surface strongly convex so that the lateral margins are not visible when viewed from above ; sparsely and finely punctate ; the interspaces granular. Scutellum much wider than long ; with the surface granular. Elytra narrow behind, the base wider than pronotum; no callus or intrahumeral groove ; with the surface convex and punctate ; the punctures close and rather strong at base, but sparse and fine towards the apex ; the interstices granular. Wings absent.

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[9] Jacoby. 1889. *Ann. Mus. St. nat. Genova,* 17:190.

[10] Weber. 1801. *Obs. Ent.,* 1:57.

Underside pubescent, punctate, granular ; prosternum with the margin narrowly grooved strongly arched and narrow ; first hind tarsal segment nearly half the tibiae ; last adbominal sternite in male lobed in the middle, but entire in the female.

Aedeagus with the median lobe tubular, sclerotized, divided into anterior larger part containing the median orifice and a posterior smaller part containing the large median foramen, the point of fusion of these two parts is constricted ; dorsal side convex ; extending over the median orifice; ventral side flat, extending anteriorly beyond the orifice to form a narrow spear-shaped tip; this side with a large groove running the whole length of the mediam lobe ; tegmen Y-shaped, dorsal prolongation absent ; internal sac membranous without visible sclerotized armature.

Length 1.8 mm, width 1.0 mm.

Holoytype one female, *allotype* one male and *paratypes* two examples; Rohtang Pass, 4000 metres above mean sea level, under stones (Summit of Pir Panjal Range), Coll. A. P. Kapur, 5-vi-1955 ; also one example from Dhorni (Lahaul Valley) North slopes of Pir Panjal Range, 3600 metres above mean sea level, Coll. Santokh Singh, 13-vi-1955.

The body is narrower in two males ; antennae longer and slender ; palpi and antennae brown ; punctures on pronotum and elytra finer.

This species is close to *Longitarsus fumidus* Maulik,[11] but differs in the much shorter antennae, the second antennal segment being never shorter than the third, smaller body and other characters. The colour of elytra, antennae and the length of latter distinguished it from *L. championi* Maulik.[12]

Nonarthra variablis Baly

1862. *Nonarthra variabilis*, Baly, *J. Ent.*, 1:456.
1926. *Nonarthra variabilis*, Maulik, Fauna British India, Coleoptera, Chrysomelinae & Halticenae.

I have before me the following material : 3 examples : Manali, Sta. No. 2, 1830 metres above mean sea level, Coll. Santokh Singh & V. K. Gupta, 1-6.vi. 1956. Black except the basal four antennal segments which are brown. Pronotal anterior angles and lateral area brown. 1 example from Manali, Sta. No. 2, Coll. Santokh Singh, 6-vi-1956 ; Head black, antennae with the first four segments black above otherwise dark brown, rest of antennal segments black ; pronotum with the antero-lateral border brownish-black, rest of the

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[11] Maulik. 1926. Fauna of British India, Coleoptera : Chrysomelidae ; Chrysomelinae & Halticinae , p. 344.

[12] Maulik. *op.cit.*, p. 358.

pronotal surface completely black ; scutellum black ; elytra reddish-brown; underside entirely black, including legs. 1 example; Manali, Sta. No. 2, Coll. V. K. Gupta, 3-vii-1956 ; head with the labrum yellowish-brown, except for the two tringular black spots on vertex ; first four antennal segments brown, rest of antennae black ; pronotum yellowish-brown ; scutellum brown with the margins black ; elytra yellowish-brown ; margin beyond the middle with a black longitudinal band, apex also black ; suture very narrowly black ; underside black, fore and mid legs wholly yellowish-brown ; hind legs black at apex of femora and tibiae, rest yellowish-brown. 1 example : Manali, Sta. No. 2, Coll. V. K. Gupta, 1-vii-1956 ; head black; basal four antennal segments brown, rest of antennae black ; pronotum yellowish-brown ; scutellum black ; elytra yellowish-brown ; underside wholly black, except tibiae which are yellowish-brown. 4 examples : Sissu, 3200 metres above mean sea level, Lahaul Valley, south slope of Great Himalaya, Coll. A. P. Kapu-, 10-vi-1955.

Above the carina on the vertex there is an excavation not mentioned in the original description or by Maulik (*loc. cit*).

Distribution.—Kumaon and Garhwal, North-West Himalaya.

Podagarica alticus, sp. nov.

Fig. 2 B, 4 E.

Body strongly convex, shortly ovate ; upper surface entirely shiny-black except the labrum which is slightly brownish ; antennae with the four segments brown, fifth to eight segments blackish, ninth to eleventh segments lighter than the preceding but darker than the first four segments ; underside black ; legs brown, with the apices of femora and tibiae black.

Head with the labrum slightly wider than long, with a row of distinct setigerous punctures along the median transverse line, convex and smooth ; clypeus not raised to the same level as labrum, from which it is difficult to distinguish the clypeus at first sight ; posteriorly produced into a median and rather strongly swollen and broadened interantennal carina, which is punctate and pubescent ; frontal tubercles transverse, subglobose, widely separated from each other as well as from the carina by a deep transverse groove ; vertex separated from frons by a transverse sinuate groove, foveolate near eyes ; between eyes and frontal tubercles with a few deep punctures ; vertex smooth. Antennae short, extending a little beyond the base of elytra ; first segment the longest and stoutest, the second segment shorter than the third ; the third segment longer than the fourth ; fifth segment shorter than fourth ; sixth and the succeeding segments gradually elongated and thickened. Eyes entire. Pronotum nearly one and a half times wider than long ; the sides distinctly margined, anteriorly narrowing and rounded ; posteriorly nearly parallel-sided ; anterior margin straight ; posterior margin sinuate and lobed in the middle ; anterior angles swollen and slightly produced ; surface convex, sparsely punctate, the punctures larger in the middle in between the two lateral longitudinal impressions on the base ; lying within the posterior angles and perpendicular to the base are two short longitudinal deep grooves usual in the genus ; basal sulcus absent ; area between these longitudinal grooves very indistinctly flattened but not depressed or grooved. Scutellum triangular, with apex rounded, smooth. Elytra wider than pronotum, widest in the middle ; narrowing to rather an acute apex ; the sides with distinct margins ; surface highly convex ; punctate-striate ; the punctures well apart from each other ; seven distinct rows of punctures including the short scutellar row ; strong at base, but becoming abruptly finer beyond the basal third ; the area laterad of the seventh row of punctures with very minute and sparse punctures (visible only under higher magnifications) apex very acute. Wings absent.

Underside pubescent and punctate ; prosternum narrow, slightly incarassate, strongly punctate ; mesosternum broad ; epipleurae broad, extending to the apex of elytra ; first tarsal segment large and broad ; last abodminal sternite lobed in male as in other Halticinae ; in the female without such a lobe. Aedeagus with the median lobe tubular; the anterior larger part encloses the internal sac; the basal smaller part nearly one-fourth the length of the aedeagus median foramen occupies this whole posterior one-fourth ; dorsal side convex, ending over the orifice ; at the two sides of the orifice there are two short sclerotized strips; the lower side extends beyond the orifice and narrowed to a pointed apex ; lower side with a groove, extending almost the whole length of the anterior part of the median lobe ; internal sac membranous.

Length 2.4 mm, width 1.3 mm.

Holotype one female, *allotype* one male: About 3.2 Kilometres north of Rahla, south slope of Pir Panjal Range, 3657 metres above mean sea level, Coll. A. P. Kapur, 31-v-1955 (from under stones).

This species differs from *P. semicoerulea* Jac[13]. in size, colour and in the longitudinal impression on pronotum. The impression in this species is from the posterior margin, but in *P. semicoerulea* it is from the anterior margin.

Sabaethe troglodytes (Oliver)

1808. *Altica troglodytes*, Olivier, *Entomologie*, 6: 700, fig. 58, pl. iii.
1926. *Sabaethe troglodytes*, Maulik, Fauna British India, Coleoptera ; Chrysomelidae; Chrysomelinae & Halticinae, p. 390.

I have before me 5 examples : Manali, 2000 metres above sea level, Sta. No. 5, Coll. R. L. Kotpal, 25-vi-1956, Coll. Santokh Singh, 25-vi-1956 and 6-.ii-1956

This is the first record of the species from the region of the North-West Himalaya.

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[13] Jacoby. 1909. *Ann. Soc. ent. Belgique*, 47 : 109.

Distribution.—Bengal, Bihar, Burma, lower reaches of the Himalaya from River Brahmaputra (915 metres above mean sea level) to Kumaon and Dehra Dun.

Subfamily GALERUCINAE

Galerucella placida Baly

1878. *Galerucella placida*, Baly, *Cistula Ent.*, 2:381.
1926. *Galerucella placida*, Maulik, Fauna British India, Chrysomeline & Halticinae, p. 217.

I have before me 6 examples : Katrain (Kulu Valley), 1675 metres above mean sea level ; Manali 2500 metres above mean sea level, Sta. 2, Coll. Santokh Singh, 23-24. vi. 1956 ; Coll. H. N. Baijal, 24-vi-1956.

Distribution.—Kashmir, Kumaon, Bihar, Bengal, Coromandal Coast of South India ; Burma.

Hoplosoma sexmaculata (Hope)

1831. *Auchenia sexmaculata*, Hope, in *Gray Zool. Misc.*, p. 29.
1936. *Hoplosoma sexmaculata*, Maulik, Fauna British India, Coleoptera ; Chrysomelidae; Malerucinae, p. 154.

I have before me 3 examples : Manali, 1830 metres above mean sea level, Sta. No. 1, Coll. Santokh Singh, 25-vi-1955 ; 1 example : Katrain, Coll. Santokh Singh, 27-vi-1956.

Elytral spots : The post-median spots fused together ; the size of the spots variable in the specimens before me ; depression on pronotum is not even but interrupted in the middle by a fine longitudinal ridge ; mesosternum pale yellow like the rest of body and not dark brown or piceous. Though Maulik (*loc.cit.*) does not mention, the males and females can be easily distinguished one from other as follows : Male length 7.5 mm. last abdominal sternite with a triangular groove, over which bends the shiny pygidium; antenna slender. Female length 9.0 mm. pygidium and last sternite both triangular ; the sternite has the lateral short depressed areas, one on each side ; antennae somewhat stouter than in male.

Distribution.—Common on the outer ranges of the Kumaon, Garhwal and North-West Himalaya, also reported from Nepal Valley and extending into China, and also found in Assam.

Macrina armata Baly

1878. *Macrina armata*, Baly, *Cistula Ent.*, 2:377.
1936. *Macrina armata*, Maulik, Fauna British India, Coleoptera ; Chrysomelidae ; Galerucinae, p. 561.

I have before me 1 male and 16 females : Manali, 1830 metres above mean sea level, Coll. A. P. Kapur, 25-vi-1955 ; 2 males, Manali, 2285 metres above mean sea level, Coll. A. P. Kapur, 24-vi-1955 and 1 female, Katrain, 1675 metres above sea level, Coll. A. P. Kapur, 24--vi-a1955.

Distribution.—Darjiling (Eastern Himalaya) and outer ranges of the region of the North-West Himalaya.

Merista quadrifasciata (Hope)

1831. *Galeruca quadrifasciata,* Hope in *Gray Zool. Misc.* p. 28.
1936. *Merista quadrifasciata,* Maulik, Fauna]British India, Coleoptera; Chrysomelidae; Galerucinae, p. 149.

I have before me 1 example : Katrain, 1675 metres above mean sea level, Coll. A. P. Kapur, 24-vi-1955.

Vertex with distinct fovea ; abdomen unicolourous, without lateral black spots.

Distribution.—Widely distributed on the lower ranges of the Himalaya, from Assam to Abbotabad.

Subfamily HISPINAE

Dactylispa brevispinosa (Chap).

1877. *Hispa brevispinosa,* Chapius, *Ann. Soc. ent. Belgique,* 20:56.
1919. *Dactylispa brevispinosa,* Maulik, Fauna British India, Coleoptera ; Chrysomelidae; Hispinae & Cassidinae, p. 183.

I have before me 1 example : Manali, 1830 metres above mean sea level, Coll. A.P. Kapur, 21-vi-1955.

Distribution.—Assam (Khasi Hills 300-900 metres); Kangra Valley (Punjab) 1220 metres ; region of the North-West Himalaya.

Subfamily CASSIDINAE

Cassida syrtica Boh.

1856. *Cassida syrtica,* Boheman, *Cat. Col. Ins. British Mus.,* 9:129.
1919. *Cassida syrtica,* Maulik, Fauna British India, Coleoptera : Chrysomelidae ; Hispinae & Cassidinae, p. 388.

I have before me 1 example : Manali, 2000 metres above mean sea level, Sta. No. 3, Coll. H. N. Baijal, 24-vi-1956.

The four apical antennal segments gradually become darker ; legs light brown ; pronotum basally with two lateral, small, circular and a median V-shaped spot.

This species is being recorded here for the first time from the region of the North-West Himalaya.

Distribution.—Widely distributed all over India and often found on the lower reaches of the Himalaya.

Cassida nigriventris Boh.

1854. *Cassida nigriventris*, Boheman, Mon. Cass., 2:410.
1919. *Cassida nigriventris*, Maulik, Fauna British India; Coleoptera ; Chrysomelidae; Cassidinae & Hispinae, p. 375.

I have before me 5 examples : Manali, 1980 metres above mean sea level, Coll. Santokh Singh, 23-vi-1955; 2 examples: Katrain, 1470 metres above mean mean sea level, Coll. Santokh Singh, Sta. 58, 27-vi-1956.

Head yellow ; terminal antennal segment darker ; posterior and lateral margins of abdominal sternites yellow ; elytra with only 9 rows of punctures.

Distribution.—Lower ranges of the Himalaya from Darjiling through Sikkim, Kumaon, Garhwal, North-west Himalaya and some parts of Tibet.

FAUNISTICS, TAXONOMY, FIELD ECOLOGY, ADAPTATIONS AND ZOOGEOGRAPHY OF THE HIGH ALTITUDE INSECTS FROM THE NORTH-WEST HIMALAYA*

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The North-West Himalaya, also called the Punjab Himalaya, lies between the rivers Sutlej and Indus. While east of the river Sutlej, which cuts across the Himalaya, the peaks rise to over 7000 metres above mean sea level, most peaks rise to only 6000 meters in the North-West Himalaya. The trend-line of the North-West Himalaya is also different from the rest of the Himalaya. While the rest of the Himalaya lies between 27° and 29° North Latitude, the North-West Himalaya stretches from 31° to 36° North Latitude. There are a series of nearly parallel ranges, *viz.* the Siwaliks, the Dhaula Dhar, the great Pir Panjal, the Great Himalaya, Zaskar, Ladakh and the trans-Himalayan Karakoram ranges. The major rivers belong to the antecedent river system characteristic of the Himalaya and have longitudinal valleys before turning more or less abruptly to the South. The northern slopes are rugged, barren and often enclose high meadows with lakes, but the southern slopes are covered with forests, at least in the outer ranges, and have no high plains.

The general climatic conditions are very similar to those prevailing in Tibet. Owing to the higher latitude, differences in the trend-line of the ranges and the greater width, there is practically no rainfall beyond the Pir Panjal Range. The permanent snow-line facing the south and south-west is thus much higher than in the eastern Himalaya and is generally not below 5180 metres above mean sea level. The region is characterized by great aridity, constant, fierce, cold , dry winds, prolonged and severe winter, short and late summer and high glare. Even in mid summer the maximum air temperature in the open is generally low. Due to the reduced atmospheric pressure, the generally high wind velocity and the low atmospheric humidity, evaporation from exposed surfaces is extremely rapid. Compared with other parts, the timber-line in the North-West Himalaya is lower ; it varies from 3657 metres on the Dhaula Dhar to about 3000 metres or even less on the Pir Panjal. Ladakh, Zaskar, Lahaul and Spiti beyond the Pir Panjal, are largely snowy deserts. High glare due to reflection from snow and great ultra-violet radiation are other important prevailing condtions. Above the timber-line there is very little soil and the rock is generally sparsely covered by algae, moss and lichen. Owing to the complete absence of trees of any kind and the restriction of the growth period of even low-matted vegetation of dwarf plants of the high meadows to the all-too-short summer of hardly 8 weeks, there is a general scarcity and lack of variety of food.

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*An abstract of the thesis submitted for the Ph. D. degree of the Agra University in 1958.

The high altitude insects inhabit the life zone extending from 1500 metres to over 6000 metres above mean sea level. Nearly 2400 species belonging to about 1000 genera of 16 Orders have so far been found to be the inhabitants of this extensive belt. With increase of altitude there is a succession of species and rapid fall in their numbers. The timber-line (3000 metres above mean sea level) represents a natural boundary between two ecologically very different groups of insects *viz.* the taiga insects and the nival insects. The nival insect fauna represents about 16% of the total high altitude insects known from the North-West Himalaya.

The nival insects constitute an ecologically highly specialized fauna, inhabiting the montane tundras above an elevation of 3000 metres and characterized by prolonged hibernation under snow-cover. Nearly 400 species representing 14 Orders, are at the present known to constitute the nival insect fauna of the region. Coleoptera represent almost one-half the nival fauna and Lepidoptera about one-fourth. There are reasons to believe that Diptera occur in much larger numbers than known at present. Odonata are very poorly represented. Orthoptera include many interesting forms like *Conophyma*, *Gomphomastax* and *Sphingonotus*. Dermaptera are represented by the mountain-inhabiting Anechurinae. Heteroptera include such interesting species like *Nysius ericae* (Schill.), and *Chlamydatus pachycerus* Kirit. In Coleoptera the families Carabidae, Staphylinidae, Tenebrionidae and Curculionidae are dominant and include many genera like *Amara*, *Bembidion*, *Cymindis*, *Nebria*, *Trechus*, *Geodromicus*, *Atheta*, etc. Bombidae and ants are also common. In Lepidoptera the dominant families are Papilionidae, Pieridae and Nymphalidae, with genera like *Parnassius*, *Argynnis* and *Colias*. Collembola are common everywhere.

Most of the species of the nival insects occur at elevations between 3500 metres and 4500 metres, but several like *Nysius ericae alticola* Hutchinson, *Chlamydatus pachycerus* Kirit., *Tibetocoris margaretae* Hutchinson, *Amara brucei* Andr., *Bembidion nivicola* Andr., *Atheta* (*Dimetrota*) *hutchinsoni* Cam., *Parnassius delphius workmani* Avinoff, *Colias leechi* Gr., etc., often occur at elevations above 5000 metres. Many species inhabit elevations above the permanent snow-line.

Reports of identifications of the species collected from the North-West Himalaya are summarized in Appendix II Part I. Descriptions of several new species of Chironomidae (Diptera) *viz.* *Brillia kultia*, *Metriocnemus* (*Heterotrissocladius*) *kuluensis*, *Metriocnemus* (*Heterotrissocladius*) *chandra*, *Orthocladius* (*Pseudorthocladius*) *virendri*, *Trichocladius bryophila*, and *Chironomus* (*Paratendipes*) *lahaulensis* are included here. All the high altitude insects, including the nival species (Part I, Appendix I), have been catalogued in four check-lists, three of which have been published and the fourth is in the press.

Atmoshperic cold, atmospheric aridity and local conditions are the most important of the various environmental conditions which influence the nival insects. The great importance of microclimatic conditions is discussed.

A wide range of microclimatic niches with optimal conditions for a great variety of insects is found nearly upto an elevation of 6000 metres. The biotic factors include overcrowding, nutritional conditions and isolation. Altitude and aspect (slope) of the mountain ranges very profoundly modify the influence of other environmental factors. The specialization of nival insects deals with adaptations to cold, pronounced hygrophily, general reduction in size, limitation of locomotion, endogeous habits and preference for snow-cover. There is also a great preponderance of flightless, carnivorous, carion-feeding or debris feeding forms. The nival insect communities include both terrestrial and aquatic types : (i) barren rock communities, (ii) vegetation-mat communities, (iii) understone communities, (iv) soil communities, (v) snow communities, (vi) glacial lake communities, (vii) torrential communities and (viii) hot spring communities.

The special ecology of 14 Orders of nival insects is dealt with. Many Orthoptera and Heteroptera are found on alpine meadows or on *Artemisia* steppes. Most Coleoptera generally occur under stones in the neighbourhood of streams and edge of the receding snow. Collembola are found on snow-fields and soil.

The nival insect fauna is characterized by the high degree of endemism, amounting to nearly 60%. The Palaearctic elements constitute 95%, of which the Mediterranean element represents only 4·0 %. The Indo-Malayan faunal elements are represented by only 14 species, amounting to 3·5% of the nival fauna. There is high proportion of Central-Asian and Tibetan elements in the nival insect fauna.

The distribution of nival species are characterized by very pronounced localization, discontinuity, concentrations in small isolated localized patches and allopatric isolation on high massiffs. There is a very pronounced massing of species around high ridges and peaks and in the neighbourhood of present day glaciers and in the areas which were heavily glaciated during Pleistocene. There are three centres of endemism, on the basis of which, the North-West Himalaya is subdivided into three faunal provinces.

SECONDARY GROWTH IN *URTICA DIOICA* L.

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INTRODUCTION

Islands of unlignified parenchyma embedded inside the xylem is not of common occurance. Solereder (1908) has reported the presence of such unlignified parenchymatous tissues in the secondary wood of *Cissus*, *Olinia*, and *Urtica*, and Metcalfe and Chalk (1950) in several members of Urticaceae family. However, Sayeedud-din and Salam (1942) have not reported the presence of unlignified parenchyma in the xylem of *Pilea*, *Pellionia* and *Holoptelea*, some members of the Urticaceae family.

In the present work *Urtica dioica* L. was taken up specially to study the formation of unlignified patches of parenchyma in the secondary xylem of the various organs. To the knowledge of the author there is no detailed account available in English language on the secondary growth in *U. dioica.*

MATERIAL AND METHODS

The material used in this study was locally collected by the author first in spring in the month of April when the new plants were coming up and then in autumn in the month of November. The material for study was fixed in formalin-acetic acid-alcohol and sections were mostly cut on the sliding microtome. Safranin and fast green were used for staining.

THE STEM

Young stem of *U. dioica* shows collateral vascular bundles arranged in a ring. From a very early stage inter- and intra-fascicular cambium become active so as to form a continuous cylinder of secondary xylem on the inner side and of secondary phloem on the outer side, both are traversed by narrow medullary rays. The secondary xylem in the very beginning is formed of vessels and xylem parenchyma.

The only anomaly in the cambium activity in the stem is that at places, in place of xylem cells, it forms patches of parenchymatous cells on the inner side for a brief period, which do not get lignified. However, soon the portion of the cambium resumes its normal activity producing the usual secondary xylem elements. This process is repeated several times giving rise to a number of 'islands' of parenchymatous cells embedded in the thick walled cells of the wood. Cells of the included parenchymatous islands do not get lignified. These islands of unlignified parenchyma surrounded by the xylem tissue give an impression of interxylary phloem (Fig. 1 & 2 ; Plate I) but no transformation of such cells into sieve tubes has been noticed by the author. The islands of unlignified parenchyma are tangentially elongated but have no definite shape. The islands formed during the spring are numerous and large in size. The wood formed late in the year is more lignified and with lesser and smaller number of included parenchymatous islands (Fig. 1 ; Plate I). About 130 of such islands were counted in a cross section of a stem of 1·0 Cm. diameter cut in the month of November. Disintegration of the unlignified parenchymatous cells in the wood of *U. dioica* has been reported by Metcalfe and Chalk (1950) but such breaking down of the tissues in the present material has not been noticed.

THE LEAF

Petiole—A petiole in a transverse section shows a well marked grove on the adaxial side. Seven collateral vascular bundles, widely spaced, are arranged in a deeply concentric arc. Vascular bundles of the upper side (adaxial side) are smaller than those of the lower side (Fig. 3).

No secondary growth was observed in a normal petiole. Even in the petiole of the oldest leaf the number of the vascular bundles and their arrangement were the same. However, secondary growth has been noted when leaves of *U. dioica* were detached from the plant and cultured on distilled or tap water in Petridishes (Gupta, 1957). In such cases the inter- and intrafascicular cambium became active and formed secondary tissues. Secondary vascular bundles were also formed by the activity of the inter-fascicular cambium (Fig. 4). Formation of the cambium was also observed on the inner side of the vascular bundles thus encircling them (Fig. 4, 5). The secondary growth in the petiole of the cultured leaf was very slow and different from that of the stem for it showed no islands of unlignified parenchyma.

Midrib —In transverse section at different places midrib of a normal leaf showed different number of vascular bundles arranged in a ring. No secondary growth was observed in the midrib of a normal leaf (Fig. 6). However, like that of the petiole, secondary growth was observed in the midrib of a leaf which was cultured on distilled or tap water (Fig. 7).

THE ROOT

A young root in transverse section showed tri- or tetra-arch radial vascular bundles in which secondary growth started at an early stage. The primary xylem strands meet in the centre to form a solid xylem strand. Cambium formed secondary phloem on the outer side which was formed of sieve tubes, companion cells and phloem parenchyma. On the inner side the cambium formed secondary xylem which was formed of xylem vessels, xylem parenchyma and islands of unlignified parenchyma which got embedded inside the secondary xylem. A number of broad medullary rays are also formed by the cambium (Fig. 8; Plate II).

The islands of parenchymatous cells inside the xylem are formed in the same way as in the stem. These are irregular in shape but more or less tangentially elongated (Plate II). The only major difference in the secondary wood of the root from that of the stem is that in the former case a secondary cambium often develops on the inner side of the included island of unlignified parenchyma (Fig. 8 ; Plate II). Such a cambium would look like the cambium situated below the interxylary phloem of *Strychnos* stem (Scott and Brebner, 1889). Formation of a secondary cambium has been reported around the interxylary phloem in the roots of certain Crucifers (Weiss, 1883) ; Cucurbitaceae (Scott and Brebner, 1889) ; *Ipomoea batatas* (Artschwager, 1924) ; and *Salvadora* (Singh, 1944) and in the stems of *Leptadenia spartium*, *L. reticulata* (*Singh*, 1943) and *Salvadora* (Singh, 1944).

SUMMARY AND CONCLUSIONS

It may be said in conclusion that islands of unlignified parenchyma are cut off by the cambium at places on its inner side both in the stem and the root. Subsequently the cambium resumes its normal activity and the parenchymatous islands become more and more deeply embedded into the wood. In the case of the root, differentiation of a secondary cambium at a later stage on the inner side of the included unlignified parenchymatous islands has been observed.

Normally no secondary growth has been observed in the petiole and midrib of a leaf. But when leaf is detached and cultured on distilled or tap water in Petridishes a slow activity of the cambium was noticed forming secondary tissues. However, the secondary growth in the detached leaf was different from the secondary growth in the stem and root.

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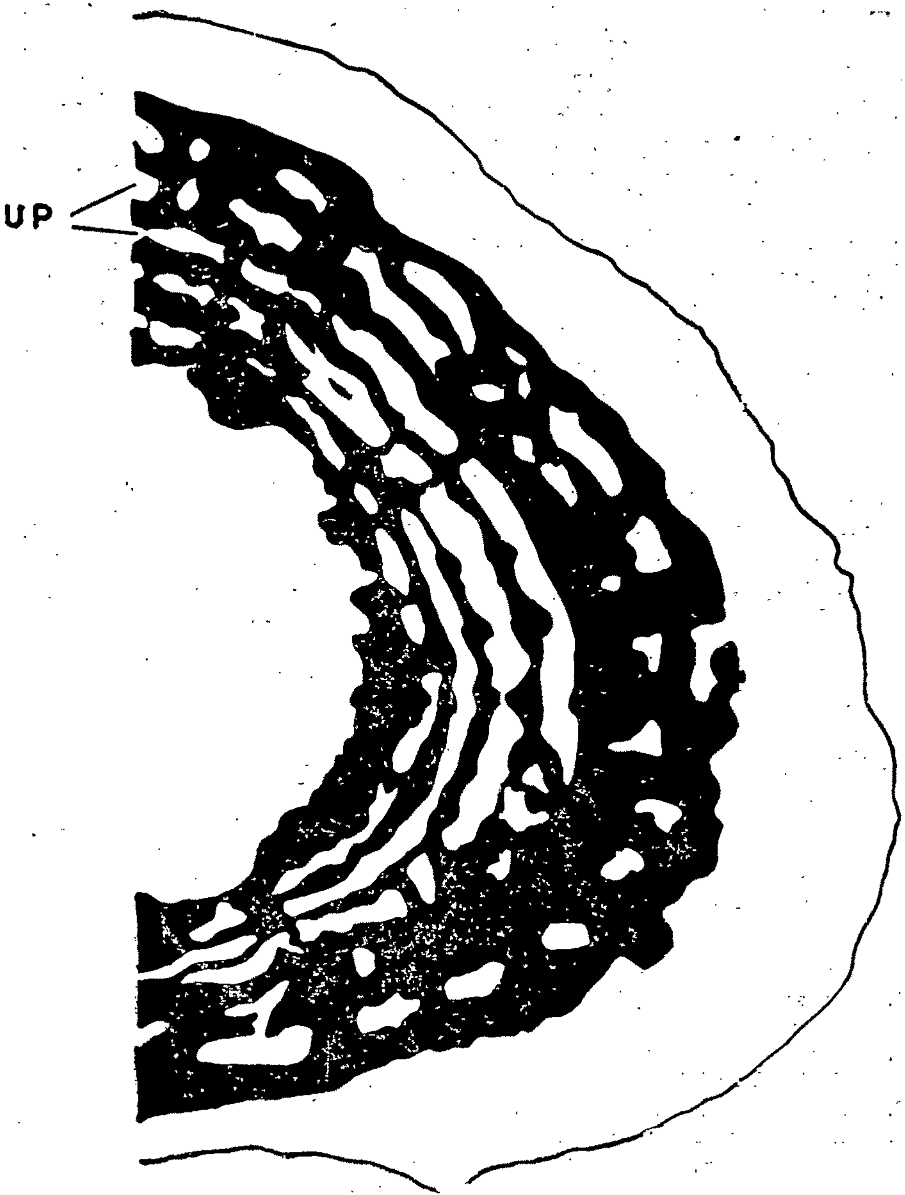

Fig. 1. T. S. of an old stem showing unlignified parenchyma (UP). X12.

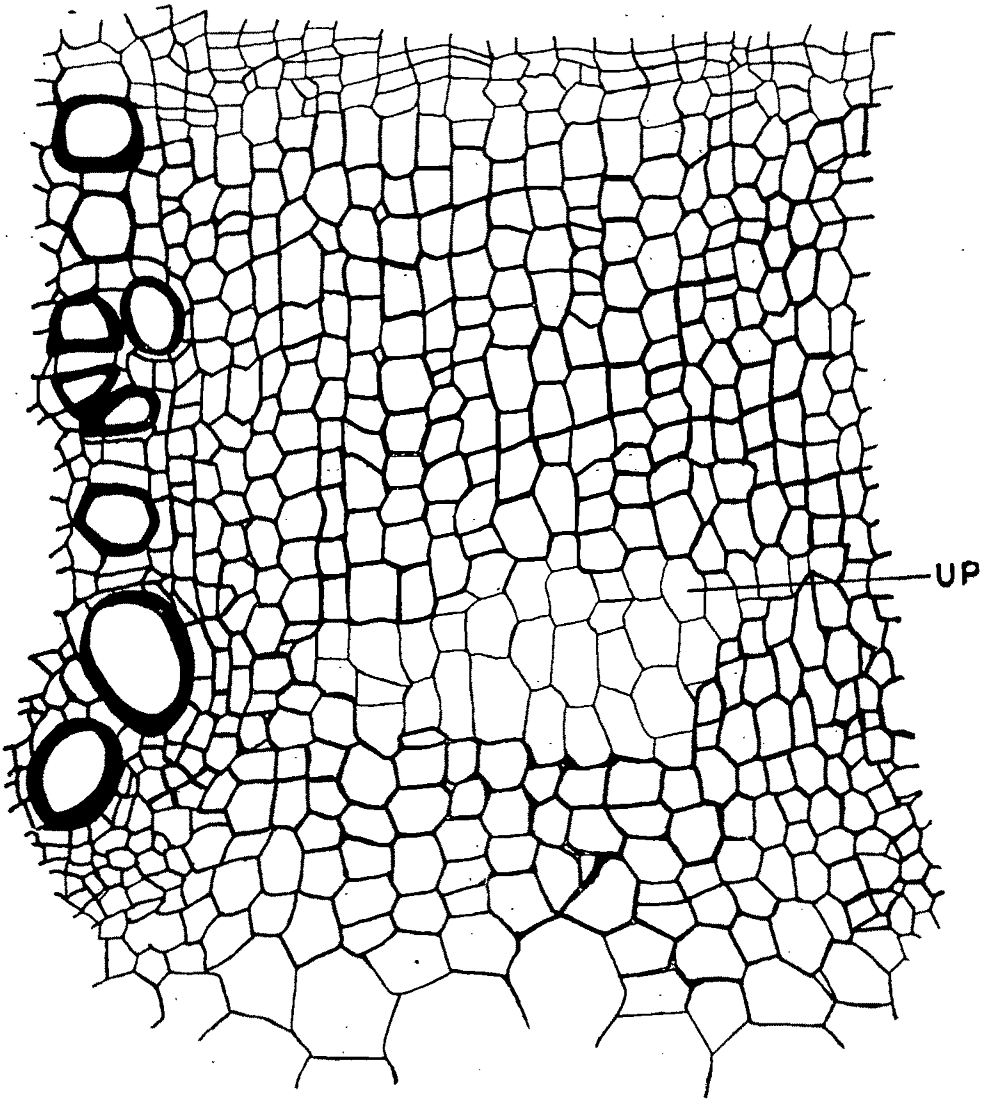

Fig. 2. A Portion of T. S. of stem showing unlignified parenchyma (UP), X150.

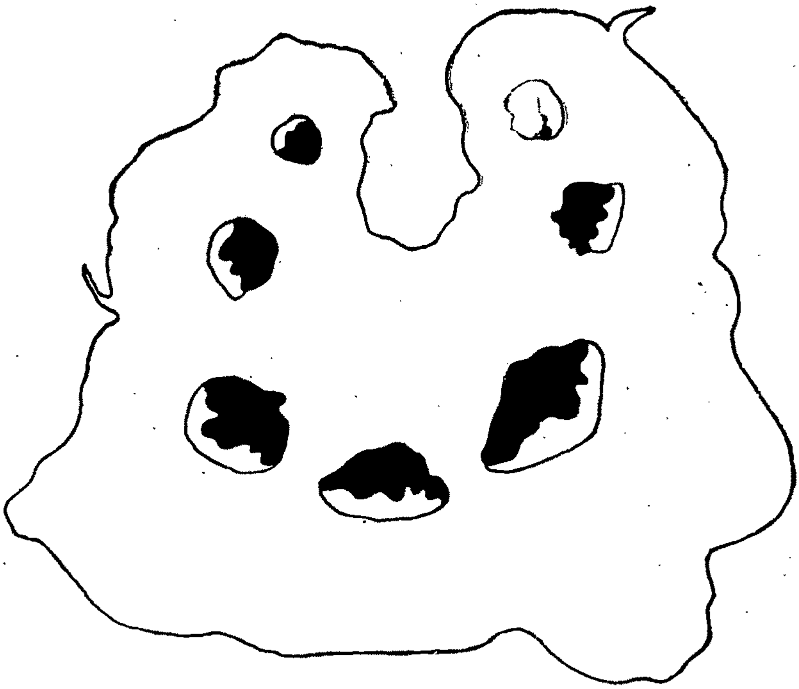

Fig. 3. T. S. of normal petiole, X35.

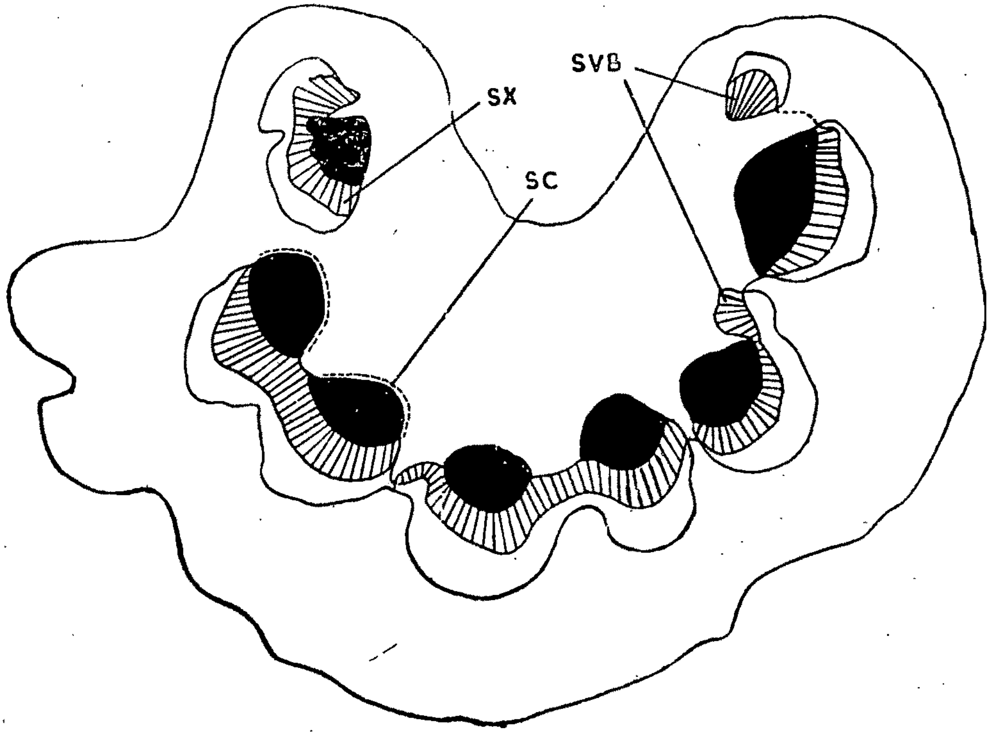

Fig. 4. T.S. of petiole of the cultured leaf, SVB—secondary vascular bundle, SC—secondary cambium. SX—secondary Xylem. X35.

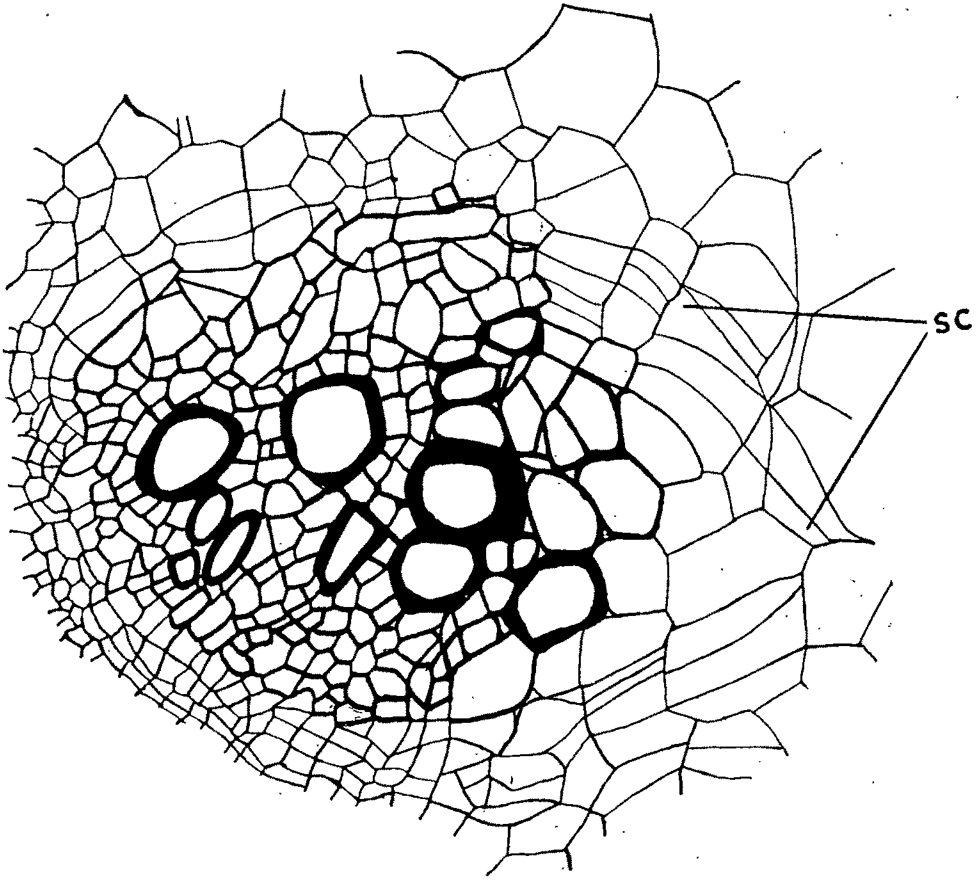

Fig. 5. A Vascular bundle of Fig. 4 to show the formation of the secondary cammbiu (SC) on its inner side, X 150.

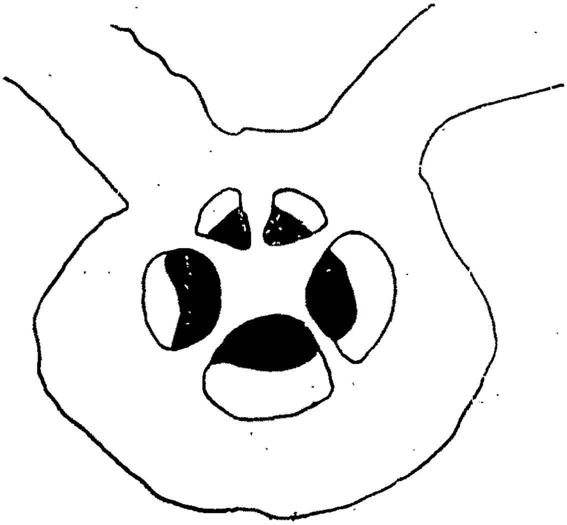

Fig. 6. T. S. of midrib of an old leaf, X35.

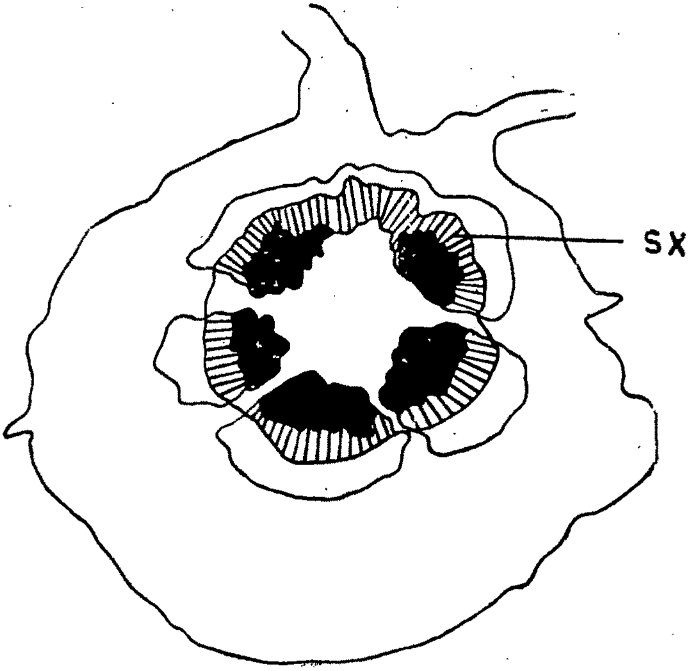

Fig. 7. T. S. of midrib of the cultured leaf, SX—secondary Xylem, X35.

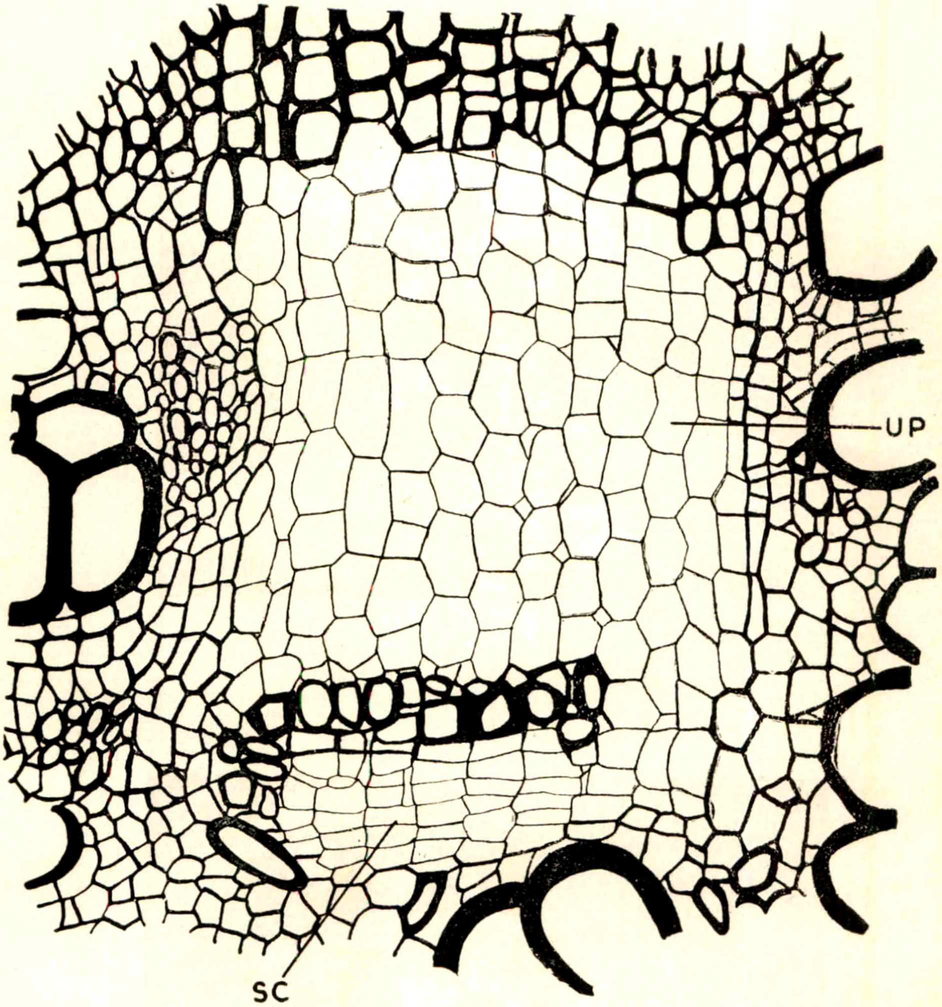

Fig. 8. A portion of T.S. of a root showing islands of unlignified parenchyma (UP) and formation of the secondary camhium (SC), X150.

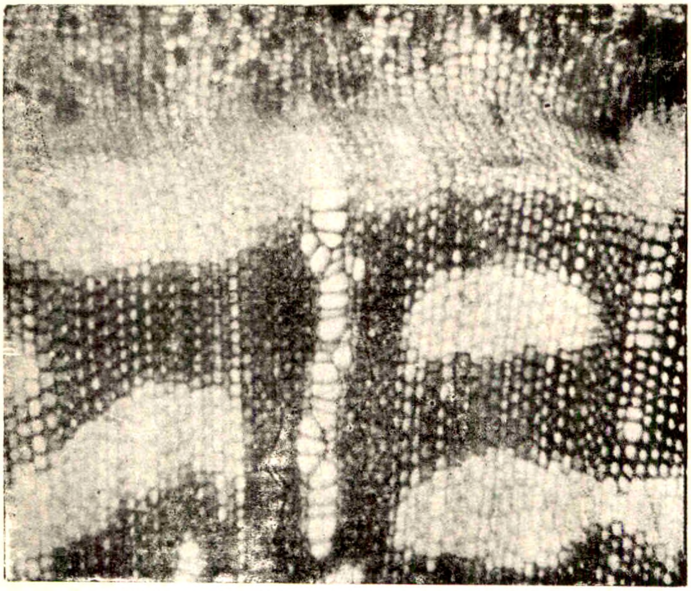

Plate I : A cross section of stem to show the formation and distribution of islands of unlignified parenchyma, X75.

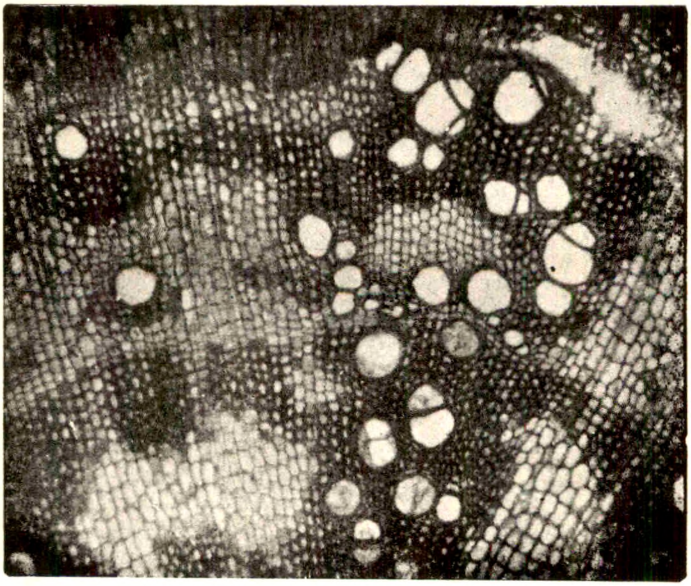

Plate II : A cross section of root to show the distribution of islands of unlignified parenchyma and formation of secondary cambium below the islands, X75.

ORGANOGENY AND FLORAL ANATOMY OF *NANNORRHOPS RITCHIEANA* H. WENDL.

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Introduction

Nannorrhops ritchieana, a xerophytic, often branched, palm (Fig. 1) is found to grow in Afghanistan and Baluchistan extending to South-East Persia (Willis, 1955; Rendle, 1956). It is a member of Palmae, the family in which sex in plants was discovered for the first time by the Egyptians in the fifth century B. C. (Maheshwari, 1950). In spite of such an early attention drawn by this family, there is not much work on the structure and organogeny of its flowers.

The present paper is a part of the investigations embodied in my thesis submitted to the University of Agra in partial fulfilment for the degree of Master of Science in 1957. This report deals with the morphology, organogeny and anatomy of the flower of *Nannorrhops ritchieana.*

Material and Methods

The buds, flowers and fruits of *Nannorrhops ritchieana* were fixed in formalin-acetic-alcohol at the Government Horticultural Research Institute, Saharanpur, with the permission of the Director, for which I express my most sincere thanks. Mr J. N. Seth also collected some material for me and his help is gratefully acknowledged. The material was dehydrated in tertiary butyl alcohol series. Serial sections were cut 8-13 microns thick and stained with either safranin-fast green or iron-haematoxylin.

Previous Work

Very few workers have studied the organogeny and floral anatomy of palms. Juliano (1926), Juliano and Quisumbing (1931) and Rao (1959a, b) have reported that in *Actinophloeus macarthurii, Areca catechu, Caryota urens, Cocos nucifera* and Sabaleae the floral organs arise in acropetal succession.

Bosch (1947) worked out the floral anatomy of twenty palms and observed that only a few vascular traces enter the outer perianth leaves while several supply the inner perianth. There is a separate vascular strand for each stamen while the carpel is supplied by a dorsal and a ventral carpellary veins.

Observations

MORPHOLOGY—The flowers of *Nannorrhops* are hermaphrodite and develop in compound panicles enclosed by two large spathes (Fig. 3). Primary and secondary branches arise in cymose manner in the axils of their individual bracts (Figs. 2, 4). The tertiary cymose inflorescences, each bearing 2 or 3 flowers, are arranged in a racemose manner on the secondary branches (Figs. 2, 5, 6). The flowers at the apices of both the primary and secondary branches are sterile (Figs. 2, 4, 5).

The mature flower of *Nannorrhops* is pinkish and a centimeter long and about the same in width. It is bracteate, pedicellate, regular, trimerous and hypogynous (Figs. 7, 8). The outer perianth whorl is formed of three, translucent gamophyllous tepals* fused almost up to their middle (Fig. 9). In transection they show an epidermis on either side enclosing a 3 or 4-layered parenchymatous mesophyll. The cells of the outer epidermis are bigger than those of the inner.

Like the outer perianth whorl, the inner also consists of three gamophyllous tepals alternating with those of the former. Their fusion is, however, restricted to the bases only. Bosch (1947) has recorded completely free inner tepals in *Sabal palmetto*. Each inner tepal is more leathery and is almost double in size as compared to the outer. It consists of an outer and an inner epidermis enclosing* a 4 to 19-layered parenchymatous mesophyll. The latter has irregularly scattered very big cells† containing raphides. These cells increase in dimensions with the growth of the tepals. The free margins of all the six tepals are dentate (Figs. 9, 10).

Stamens are arranged in two rings of three each. The bases of the staminal filaments expand laterally and fuse with one another to assume a monadelphous condition. Each stamen has a fairly long free part of filament with a four chambered versatile anther (Fig. 11). Some of the stamens have anther lobes of unequal sizes. In such cases the lower portion of the bigger lobe becomes slightly curved, still retaining a continuous chamber. The filaments also possess large cells containing raphides.

The gynoecium is syncarpous. Cross-sections of the flower at the base of the carpel, however, show that the inner margins of these carpels are free (Figs. 26, 27). Cross-sections at a higher level reveal that they possess only three deep grooves (Figs. 28-30). The tricarpellary ovary bears a single anatropous, bitegmic ovule on an axile placenta in each locule (Fig. 17). There are three clearly discernible deep grooves in the style (Figs. 35-37), as also reported by Bosch (1947) in *Sabal*. The stigma is globular and has three distinct lobes.

ORGANOGENY—The flower appears in the axil of a bract as a minute dome-shaped structure. The outer whorl of tepals arises at the base of the dome (Fig. 13), and slightly above them the inner tepal primordia also appear in the same fashion (Fig. 14). As the bud grows, the inner tepals become more prominent. The posterior inner tepal grows even faster than the other two (Fig. 15).

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* Terminology after Esau (1953).

† Such cells are devoid of protoplasm.

Very soon stamen primordia develop inner to the whorl of the inner tepals (Fig. 15). The outer stamens are formed earlier than the inner. Each stamen is, however, distinguished into a filament and an anther before the carpels are well formed. The central papilla produces three lobes which represent the three carpel primordia (Fig. 16 shows only two of them surrounded by outer whorl of stamens, the inner being not visible in this plane). Gradually, invagination takes place in each carpel resulting in the formation of a cavity in which an ovule arises from the lower free edge of the invagination.

ANATOMY—The present account of the vascular anatomy of *Nannorrhops ritchieana* agrees a good deal with that of *Sabal palmetto* (Bosch, 1947), a member of the same tribe. The differences in the vascular anatomy of these two species are discussed below.

The general course of vascular supply in the flower of *Nannorrhops* can be easily made out from Fig. 17. Two rings of vascular bundles enter the pedicel of the flower. The outer consists of 11 or12, while the inner of three bundles only. The latter are placed equidistantly and are more prominent than the outer ones. Before the inner and the outer bundles start moving towards the periphery (Figs. 19-22), some of the vascular bundles of the outer ring spread out breadthwise and divide (Figs. 18-20).

The outer tepals receive the vascular supply from both the rings. The vascular strands of the inner ring give out variable number of traces in collaboration with those of the outer ring. During this process the pith is broadened further. Each outer tepal receives one median and two lateral vascular bundles. Thus, in all nine vascular strands supply the outer tepal tube (Figs. 23-26). They may later on increase in number (Fig. 9). Bosch (1947) found only a few vascular traces entering the outer perianth in *Sabal*.

After the vascular traces of the outer perianth are formed, the main vascular bundles form a single ring from which some more traces proceed to the remaining floral organs in the following pattern: a single vascular trace from the perianth-stamen strand (Figs. 25-35) and five more from the main vascular core enter each inner tepal (Fig. 27). In this way the inner perianth whorl receives eighteen vascular strands. They may further multiply in each inner tepal resulting in 9 to 11 bundles of varying sizes (Fig. 37). Bosch (1947) observed several vascular bundles entering each inner tepal. He does not mention any common strand for the stamen and the inner perianth leaves in the various species investigated by him. This is probably due to his study by hand sections alone.

The vascular bundles follow a zigzag path in all the six tepals. They not only branch higher up but also anastomose irregularly (Figs. 9, 10, 33-38). In the inner tepals some vascular strands never reach the tip. The vascular traces to the inner tepals emerge out earlier than those of the stamens.

It is interesting to find that the vascular supply to each outer stamen is given out independently while that to each inner stamen arises as a single inner tepal-cum-inner-stamen trace (Figs. 24, 25) and runs united as long as the two organs are fused. Each outer stamen from the beginning, and every inner stamen after separation from the common trace has a single vascular bundle (Fig. 27) which bifurcates (Figs. 30-36). The two vascular bundles so formed soon reunite (Fig. 38).

As described earlier, the gynoecium of *Nannorrhops* is tricarpellary (Figs. 12, 26, 38). Bosch (1947) also found a similar condition in *Sabal.* The gynoecium receives its vascular supply from the remaining core of the vascular bundles. This core splits up into three parts, one entering each carpel. At the base of the carpel, each part forms a ring of vascular bundles (Figs. 26-29) which fans out to form a large number of laterals in the ovary wall (Fig. 30). The median dorsal bundle is prominent only at a higher level (Fig. 34). It passes straight into the style of each carpel along with a number of laterals and reaches the stigma (Figs. 35, 36, 38).

The ventral carpellary traces enter the style after supplying the ovule (Figs. 32-36) but they stop short of the stigma (Fig. 38). However, Bosch (1947) finds three vascular traces of which one enters the ovule while the other two travel as laterals in the carpel in *Sabal.*

All the vascular bundles are collateral, closed and normally oriented except the ventral carpellary traces and their branches, which are inversely oriented (Figs. 29-34).

SUMMARY

This paper deals with the floral morphology, organogeny and anatomy of *Nannorrhops ritchieana* H. Wendl. belonging to the tribe Sabaleae, of the family Palmae.

The inflorescence is a compound panicle with primary and secondary cymose branching. At the nodes on every secondary branch 2 or 3 bracteate, regular, trimerous, hermaphrodite and hypogynous flowers arise in a cymoes manner. The floral organs arise in acropetal succession.

An outer tepal receives three vascular traces from the two rings of the vascular bundles present in the pedicel. Each inner tepal is supplied with six vascular traces including a common inner tepal-cum-inner stamen trace which travels for a short distance as a fused structure. The vascular bundles in tepals may increase in number by further divisions.

A solitary vascular bundle supplies each stamen. The normally oriented dorsal carpellary veins with their branches supply the ovary wall on dorsal and lateral sides and pass directly into the style. Only the median dorsal vein continues up to the stigma. A branch of the inversely oriented ventral car-

pellary vein supplies the ovule in each carpel while the remaining enter the style but stop short of the stigma.

For his suggestion of the problem and valuable guidance during the progress of this work, as well as his painstaking perusal of the manuscript, my sincerest thanks are extended to Professor Bahadur Singh. My gratitude goes to Professor P. Maheshwari, for constant encouragement, to Dr. B. M. Johri, for useful comments and to Shri M. B. Raizada, for the identification of the plant. Thanks are also due to Mr. D. M. Sonak, for drawing figures 3-6.

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LEGENDS

FIGS. 1, 2—Habit and inflorescence. (*p*, primary branch; *s*, secondary branch; *t*, tertiary branch). Fig. 1. *Nannorrhops ritchieana* note the branched habit of the palm. Fig. 2. A part of the inflorescence. × ¼.

FIGS. 3-16—External morphology and organogeny of flower. (*br*,bract;*cp*, carpel primordium; *it*, inner tepal; *itp*, inner tepal primordium; *ot*, outer tepal; *sp*, staminal primordium). Fig. 3. A compound panicle. × ¼. Fig. 4. A primary branch of inflorescence. × ½. Fig. 5. A portion of a secondary branch of inflorescence. × ½. Fig. 6. Two tertiary cymose inflorescences. × 1½. Fig 7. An open flower, top view. × 2. Fig. 8. Same, side view. × 5. Figs. 9-12. An outer tepal, inner tepal, stamen and gynoecium respectively. × 5½. Fig. 13. L.s. floral primordium, in the axil of a bract, bearing outer tepals. × 4. Fig. 14. Same, with differentiating inner tepals. × 4. Fig. 15. Same, with stamen and carpel primordia. × 4. Fig. 16. Same, at a later stage. × 4.

FIGS. 17-26—Floral anatomy. (*ct*, carpellary trace; *itt*, inner tepal trace; *ott*, outer tepal trace; *s-itt*, stamen-inner tepal trace; *st*, staminal trace). Fig. 17. A diagram of three-fourth portion of a flower showing general course of vascular supply. Figs. 18-26. Transections at levels marked 18-26 in Fig. 17. × 2½.

FIGS. 27-38—Floral anatomy (contd.) (*dct*, dorsal carpellary trace; *ovt*, ovular trace; *st*, staminal trace; *vct*, ventral carpellary trace). Transections at levels marked 27-38 in Fig. 17. × 2½.

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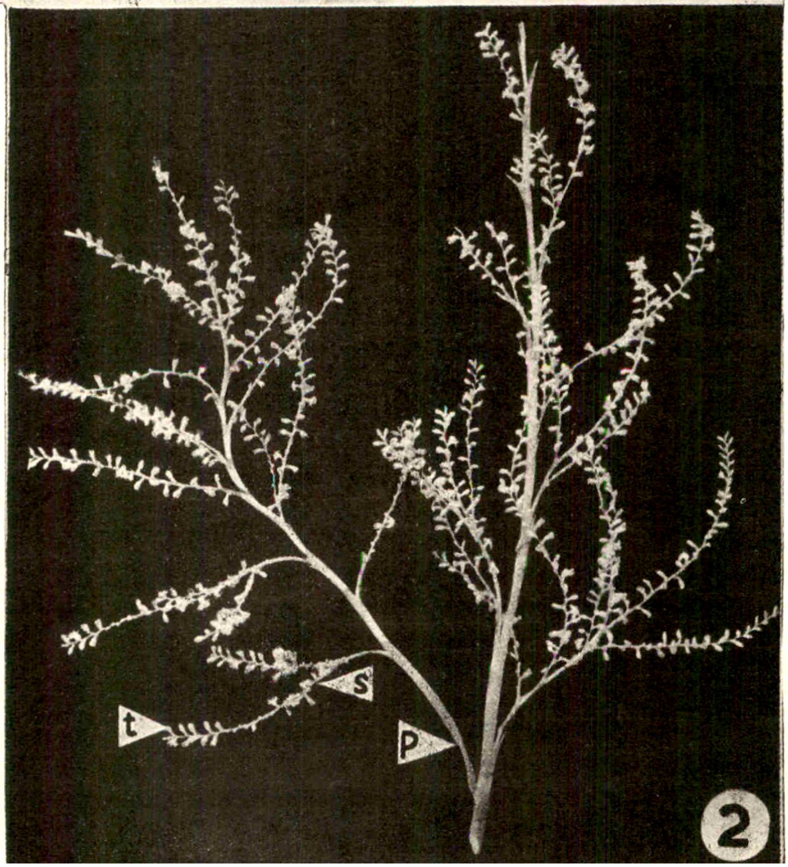
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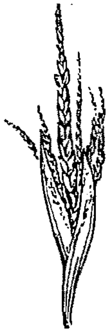
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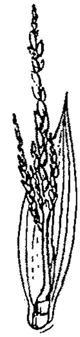
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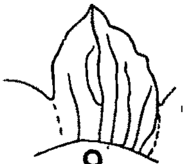
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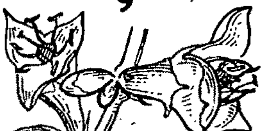
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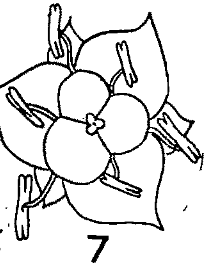
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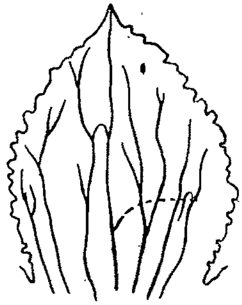
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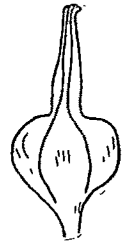
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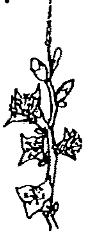
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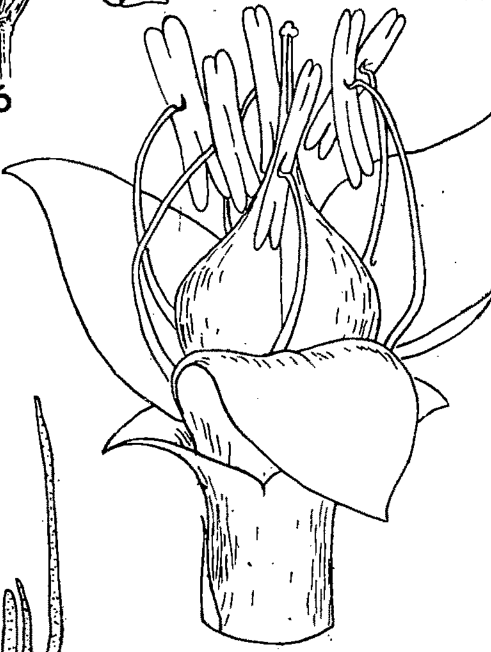
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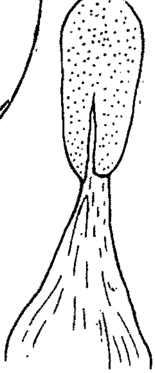
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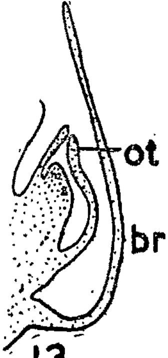

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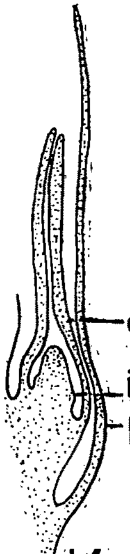

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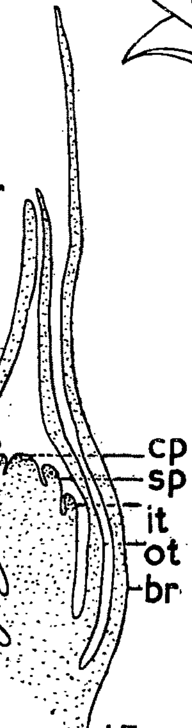

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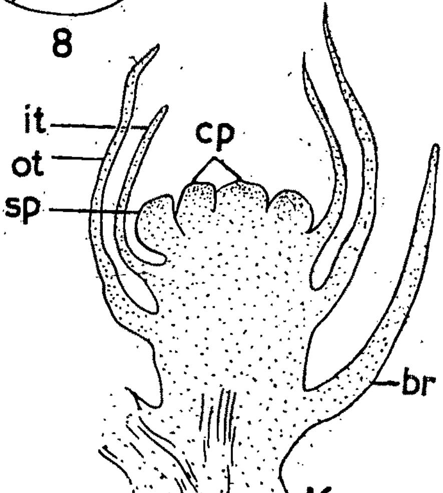

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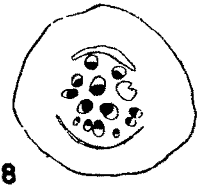

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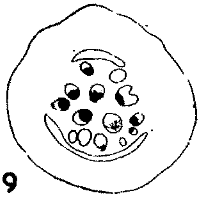

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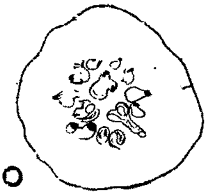

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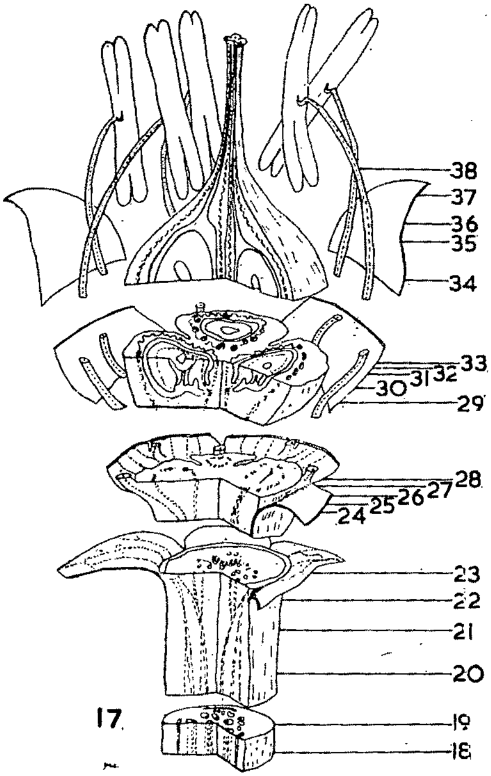

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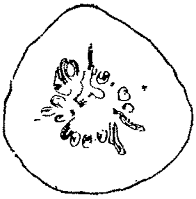

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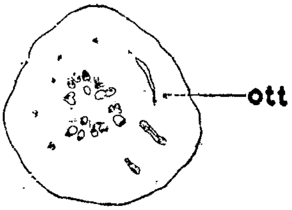

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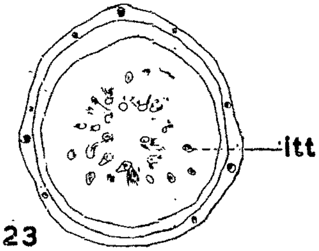

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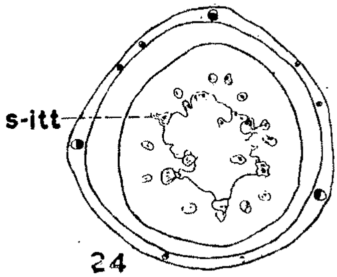

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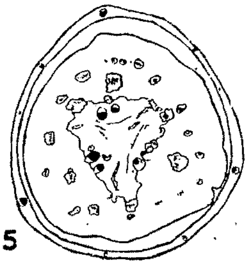

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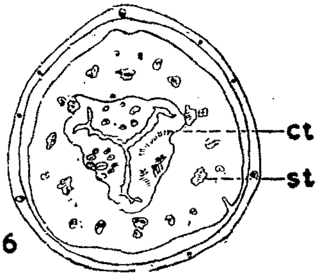

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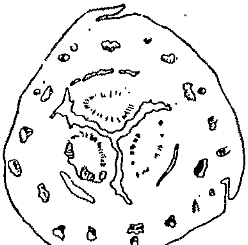
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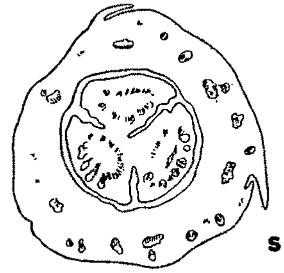
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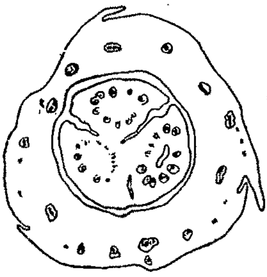
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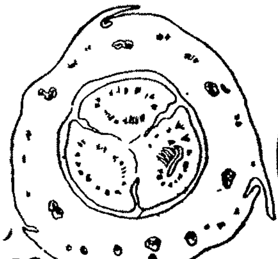
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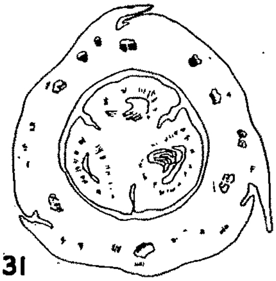
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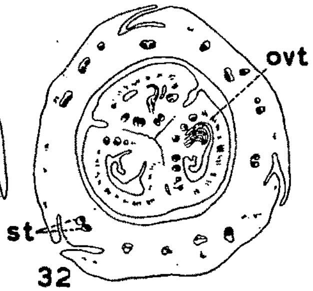

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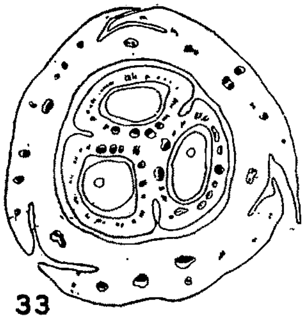
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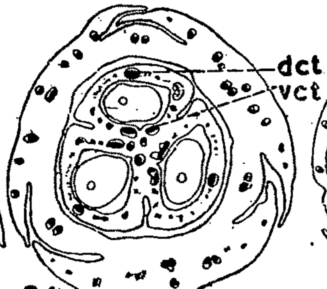

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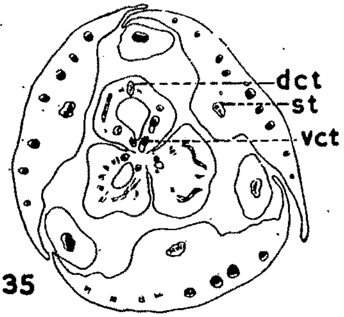

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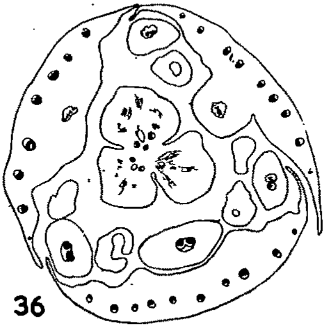
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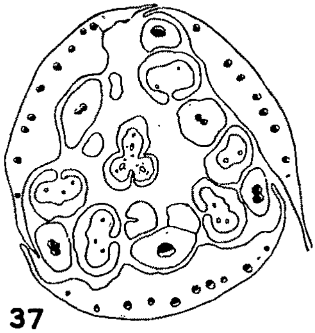
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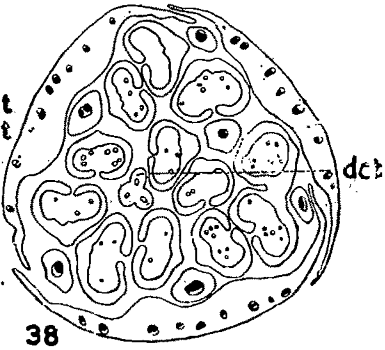

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STUDIES IN THE UMBELLALES*—I. AN ABSTRACT

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Umbellales, as treated in Engler and Prantl (1898), is a small order comprising three families—Araliaceae, Umbelliferae and Cornaceae—and is mainly distributed in tropical and temperate regions of northern hemisphere. The Araliaceae, with shrubby habit generally known as the Ivy family comprising about 63 genera and 700 species, is luxuriantly represented in almost all the tropical regions of the world with two great centres—the Indo-Malayan region and the tropical America. Umbellifers are herbaceous in nature and are cosmopolitically represented by about 270 genera and 2700 species. *Cornus*, one of the largest genera of the corraclae family (arborescent) with about fifty species, occurs in America, France and India. *C. suecica*, a small herbaceous species, extends to Lapland, Greenland and in North America to Terra Nova where a very similar herbaceous species *C. canadensis*, also grows with it.

The order Umbellales, which has always been regarded as a most highly evolved order among the polypetalous dicotyledons, has been variously treated by different taxonomists. Families, which are at present grouped in different and widely separated orders, e.g., Garryaceae (Brongniart, 1843, quoted from Lindley, 1853), Hamamelideae, Alangieae and Loranthaceae (Meisner, 1843, quoted from Lindley, 1853), Hamamelidaceae and Bruniaceae (Lindley, 1845) were at one time or another put together in the Umbellales. Besides, inclusion of Garryaceae into Umbellales is finding support from the morphological studies of Hallock (1930) and Moseley and Beeks (1955). On the contrary, some of the present day families of the Umbellales have been separated into different orders. For instance, Lindley (1833) separated Cornaceae along with Hamamelidaceae and Lorantheae into Cornales. More recently Hutchinson (1948) has asserted that the relationships of the Umbelliferae and Araliaceae are superficial due to parallelism. He suggests Araliales (Araliaceae and Cornaceae) as having the woody ancestors like Rosales and Cunoniales and the Umbellales (Umbelliferae) the herbaceous saxifragaceous ancestors.

The Umbellales of Engler and Prantl has received very little attention in the past from morphologists although its members show quite a few interesting morphological features. For example, the inflorescence, the type of placentation, the abortive ovules, number of carpels, the nature of the stylopodium and the carpophore, the sheathing leaf-bases and multilacunar nodes are some of the important features which deserve detailed attention.

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From economic standpoint also order is an important one. Some of the Aralias are tonic while others diaphoretic. *Heteropanax fragrans* is an aromatic species while *Tetrapanax papyriferum* is cultivated as an ornamental plant and is used for making 'Rice Paper' in China and Japan. Most of the Umbellifers are odourous aromatic, and many of them are used as condiments. Some, such as *Cicuta* and *Conium*, are highly poisonous to man and animals. Members of Cornaceae are rich in tannic substances.

My interest in the order Umbellales was aroused by a preliminary study of the flower of *Centella asiatica* (Mittal, 1955) which proved interesting and useful in more ways than one. A detailed investigation of all the three families was, therefore, undertaken at the suggestion of Prof. V. Puri, D. Sc., F. N. I., School of Plant Morphology, Meerut College, Meerut and an abstract of the results obtained is presented herewith.

The material, including inflorescence, buds, flowers, nodes and leaves wherever possible, was procured from various places in India (Meerut College, Meerut ; Delhi University, Delhi ; Udaipur ; F. R. I., Dehradun; Mussoorie ; Saugar University, Sagar) and abroad (British Museum Natural History, London; New York Botanical Garden, New York ; Arnold Arboretum, Cambridge ; Tasmania University, Hobart). It was treated in the usual manner for sectioning. Buds and flowers from herbarium sheets were first boiled in water for a few minutes and then treated with 5% sodium hydroxide solution at about 60°C for about 12 hours. They were then washed thoroughly with water and fixed in 70% alcohol for 3 or 4 days. Some thick sections of nodes of Araliaceae were also cut by sliding microtome and the flowers were cleared for studing their gross morphology. The present study includes 41 species, of which 21 belong to Araliaceae, 16 to Umbelliferae and 4 to Cornaceae. All the species, however, could not be studied to the same extent due to lack of material.

While in Araliaceae and Umbelliferae the nodal structure has been reported to be multilacunar (as many as 25 in *Heteropanax fragrans* and 17 in *Daucus carota*), in Cornaceae it is trilacunar and is believed to be most primitive pattern of the nodal structure. It is interesting to note that among Umbelliferae and Araliaceae, the latter which is considered to be primitive of the two receives more foliar bundles than the Umbelliferae (cf. Sinnott, 1914).

On the basis of the observations recorded in the present study, it has been concluded that there exists some correlation between the nodal structure and the size, form and mode of attachment of the leaf in three families (cf. Sinnott, 1914, page 308). For example, the multilacunar nodes of Araliaceae with comparatively larger number of traces are accompanied by large compound leaves with broad sheathing bases. Umbelliferae, having somewhat smaller number of traces (multilacunar) exhibit comparatively small, simple, profusely dissected leaves with less sheathing bases. In Cornaceae, on the other hand, the nodes are trilacunar and the leaves correspondingly are small, entire, and lack sheathing bases or any stipules. This correlation does not limit up to family level only but is also apparent at the generic level. In Araliaceae, for instance, *Hedera* and *Heteropanax* are respectively characterised by about 7 and more than 25 leaf-traces. Correspondingly *Hedera* possesses small, more or less entire simple leaves while in *Heteropanax* the leaves are large pinnately decompound. Similar correlation also holds good in different genera of Umbelliferae and Cornaceae studied here.

A very interesting feature found in the stem of *Heptapleurum venulosum* is the occurrence of few scattered cortical bundles, which has been explained by Joshi (1932) due to longitudinal course of leaf-trace bundles in the cortex.

In the petioles of some Araliaceae, the bundles at the base remain scattered and variously oriented. In the upper portion of the petiole these bundles become arranged into two rings of which the inner medullary ones are inversely oriented. The occurrence and inversion of the medullary bundles in the petioles have been variously interpreted by Worsdell (1915, 1919), Jeffrey (1917), and Joshi (1932).

Leaves in the Umbelliferae are described to be sessile or shortly petiolate, as in most cases it is the sheathing leaf-base which has taken over the function of the petiole.

While in Araliaceae and Umbelliferae the presence of the secretory ducts is a rule, in Cornaceae they are absent and are replaced by secretory cells. These ducts generally remain associated with the phloem of the vascular bundles.

The inflorescence in Araliaceae and Umbelliferae is a simple or a compound umbel. The compound umbel inflorescence is best be described as 'compound umbellose' or 'false compound umbel'. The traces for peduncules and the pedicels arise in more or less distinct whorls. This fact is interpreted to indicate that this type of inflorescence has resulted by condensation of several internodes. Simple umbel seems to be the result of the extreme reduction of the peduncules and the bracteoles of the compound umbel. The condition in Cornaceae is believed to have been obtained by further reduction involving the pedicels of the flowers.

Reduction in the number of flowers from many to one has also been reported in the central umbellet of *Daucus carota.*

The ovary in some Araliaceae and Umbelliferae is semi-inferior which is indicated by the early differentiation of the floral organs below the placental region. The vascular anatomy of the ovary has been studied in special detail, and gradual stages of adnation of floral "bundles" and their organs have been reported specially in Araliaceae. In Umbelliferae, the fusion among the traces of the various floral organs occurring on the same radii continues longer. These series, however, have been shown to be quite useless in interpreting the nature of the outer wall of the inferior ovary as the bundles which are traversing the whole length of the ovary "wall" are no doubt appendicular but have dual character. They are traces as long as they travel through the cortical region and are bundles after entering the organs concerned. And we do not have any means of distinguishing where one ends and the other begins.

Number of carpels in the formation of the gynaeceum has been found to be very variable in Araliaceae and Cornaceae. In *Tupidanthus calyptratus*, for example, there are as many as 60 or more carpels. In some cases, as in *Arthrophyllum ahernianum* and *Marlea platanifolia*, the gynaeceum appears to be monocarpellary. But anatomical evidence indicates very clearly its pseudomonomerous nature and the second carpel seems to be represented only by the relics of its ventral bundles. The latter remain mixed with those of the existing carpel for most of their length. Umbelliferae, on the other hand, has constantly two carpels and in this respect seems to have reached a stabilized stage in evolution.

The placentation in the three families is interpreted to be axile both topographically and anatomically. In some Araliaceae, the nature of the inner bundles is interpreted to be stelar and are reported to continue upward and form a central plexus which breaks up into ventral bundles in the placental region. Similar plexus formation has also been reported in other cases e. g., Cruciferae, Capparidaceae etc. This plexus formation is believed to be a primitive feature. In Apioideae of the Umbelliferae, the ventral bundles of a carpel form a V-shaped structure before giving traces to the corresponding ovules. These ventral bundles form the vasculature of the carpophore in the mature fruit, and on the basis of this fact appendicular nature of the carpophore is supported. In Hydrocotyloideae, ventral bundles of the carpels were reported to be absent. This has now been shown to be incorrect, and each ovule is supplied by a placental strand formed by the fusion of the two ventral bundles of the corresponding carpel. In *Cornus* and *Marlea begonifolia* the septum is suggested to be formed by the fusion of true carpellary margins and not by the fusion of the placental outgrowths as was suggested earlier. Evidence for such a suggestion has been obtained from the course and the behaviour of vascular bundles supplying the placentae and the ovules.

The abortive ovules, which are anatropous, and form a constant character of the Araliaceae and Umbelliferae, are completely eliminated in the Cornaceae. In this particular respect Cornaceae seems to be highly evolved of the three families. The absence of these abortive ovules has also been reported in *Tupidanthus calyptratus* (Araliaceae) and *Hydrocotyle* and *Centella* (Umbelliferae.)

The disc, which is met within all the three families on the top of the ovary, has been studied in some detail. It invariably consists of small closely packed more or less rectangular cells taking deep stain. This either continues into style or styles (Araliaceae and Umbelliferae) or forms a ring round the base of the style (Cornaceae). On the basis of its vasculature it has been interpreted in Araliaceae and Umbelliferae to be ovarian in nature, that is, being formed by "solidification" of the upper sterile region of the ovary. Consequently the disc of the Araliaceae and the stylopodia of the Umbelliferae are considered to be morphologically homologous structures. In *Marlea*, on the other hand, the disc receives a heavy vascular supply from all the peripheral bundles which supply the outer floral organs, and hence it has been interpreted in Cornaceae to be staminodal.

While in Araliaceae and Umbelliferae the style and stigma are simple structures, in Cornaceae they are a bit complicated. For example, in *Cornus macrophylla* and *Marlea begonifolia* the stylar canal was 4-lobed although the ovary below was clearly bilocular. This observation has been utilised to suggest that the ovary in the ancestral forms consisted of more than two carpels. While the additional carpels in the present day forms have disappeared in the lower region, they are still represented in the style.

The calyx and so also its vascular supply in the Araliaceae and Umbelliferae is either absent or very much reduced. In Araliaceae, the marginals of the sepals are generally derived from the adjacent petal midrib bundles. In Umbelliferae, the sepal marginals are altogether lost, and the midrib produces further branches. In Cornaceae, however, the calyx is represented by a well developed circular rim breaking into four teeth each receiving well developed traces.

The petals are, as a rule, one-trace organs in which the midrib bundles may or may not divide further. But sometimes, for example, in *Heptapleurum venulosum* petals receive three traces each from three different sources. The petal midrib traces either travel free for most of the part in the wall of the ovary (Araliaceae and Cornaceae) or arise conjoint with the carpellary bundles (Umbelliferae).

While in all cases studied the stamens as a rule are one-trace organs, in *Tupidanthus calyptratus* they receive three traces each. It may be pointed out that 3-trace stamens have been reported in several other families and this has been interpreted by Eames (1931) to be a primitive feature.

Phylogenetic relationships of the three families have also been discussed in some detail. Baillon (1881) and Hallier (1912) recognised only Cornaceae and Umbelliferae, the Araliaceae being merged into Umbelliferae. Ricket (1945) recognised two orders : the Umbellales (Araliaceae and Umbelliferae), and Cornales (Cornaceae and Nyssaceae). Recently Hutchinson (1948) revised his earlier opinion and restricted his Umbellales to Umbelliferae, and included Cornaceae in the Cunoniales (the latter a derivative of his Rosales). He treated the Araliaceae as a separate order the Araliales, derived from the Cornaceae. The inclusion of Cornaceae among Cunoniales was based on a close resemblence of the wood structure in Cornaceae and Philadelphaceae. Hutchinson further suggested that "in whatever position Cornaceae are placed, Araliaceae should accompany them".

Hutchinson considered the relationships of Araliaceae and Umbelliferae to be superficial and due to parallelism giving the following reasons :

Characters	Araliaceae	Umbelliferae
1. Habit	Almost woody	Almost herbaceous
2. Inflorescence	Simple umbel	Compound umbel
3. Stipules	Present	Absent
4. Number of carpels in ovary	More than two	Always two
5. Fruit	A berry or drupe	Schizocarpic with two mericarps.
6. Endosperm	Ruminate	Non-ruminate

On the basis of these characters he believed that Araliaceae have descended from woody ancestors, such as Rosales and Cunoniales which usually have stipules, and that Umbelliferae have been evolved from saxifragaceous stalk which agree in having no stipules, a bicarpellate ovary and are herbaceous in nature.

But Hutchinson's contention that the Araliaceae is not related to Umbelliferae does not find any support from the present study. In fact these common features such as presence of simple and compound umbels, multilacunar nodes, sheathing leaf-bases, medullary bundles in the petioles, secretory ducts, semi-inferior ovary, abortive ovules, reduced calyx, axile placentation, ovarian disc etc. found in Araliaceae and Umbelliferae reveal their natural rather than "superficial" relationships. A clsoe affinity between these two families has also been referred recently by Rodriguez (1957) basing his arguments on the study of the wood anatomy of the Umbellales. Whatever differences are there, are due to the fact that Umbelliferae has reached a stabilized stage in evolution while the Araliaceae is still in transitory stage. This holds good at least for certain features such as the number of carpels and the type of inflorescence. Of the two families, Umbelliferae on the whole, is more highly evolved.

Cornaceae is characterised by simple entire leaves, trilacunar nodes, absence of secretory ducts and medullary bundles in the petioles, cymose inflorescence, tetramerous flowers, absence of abortive ovules, well developed sepals and so on. Thus, Cornaceae seems to stand aloof from these two families in these important respects. And in view of these it does not seem advisible to log the Cornaceae with the Araliaceae. The exclusion of Cornaceae from Umbellales was suggested earlier by Sinnott (1914) and Hoar (1915) from a study of node and wood anatomy respectively. This separation has also been approved recently by Rodriguez (1957).

It would have been superfluous to comment on the affinities of the Cornaceae with other families without making a detailed study of the latter. A close relationship between Cornaceae and Garryaceae was recently suggested by Moseley and Beeks (1955) who based their conclusions on a study of the wood anatomy of *Garrya*.

In view of this brief discussion it becomes apparent that the Araliaceae and Umbelliferae should be retained together in the Umbellales while the Cornaceae should be taken out of it. Separation of *Marlea* into a separate family Alangiaceae, as was done by earlier workers, also finds support from the detailed study of the vasculature of the disc in *Marlea*.

ACKNOWLEDGEMENT

The author takes the opportunity of expressing his sense of gratitude and sincere thanks to his teacher Professor V. Puri, D. Sc., F. N. I., F. A. Sc., F. B. S. for his continued and valuable guidance, for constant interest and encouragement throughout the course of this study. He feels pleasure in recording his heartfelt thanks to Sri Madan Mohan (Meerut) and Dr. S. B. Saksena (University of Saugar) for encouragement and keen interest in his work ; and to all his friends of the School of Plant Morphology, Meerut College, Meerut for cooperation and help rendered in different ways. Lastly, to the Government of India the author is thankful for the award of a Senior Research Training Scholarship during the tenure of which most of the present work was completed.

STUDY OF CARBANION FORMATION IN α-HALOGENATED ACETOPHENONES THROUGH SYNTHESIS AND REACTIONS OF α-BROMO—α-ISONITROSO ACETOPHENONES

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SUMMARY

The carbanion formation in α-halogenated acetophenones, through synthesis and reactions of α-bromo—α-isonitroso acetophenones have been studied. Study of nitrosation reveals that in case of α-bromo acetophenones the carbanion formation takes place at methylene group.

INTRODUCUTION

In earlier communication (1,2) the authors studied the mechanisms of formylation of esters and nitrosation of ketones and brought out clearly the salient features of ethyl formate and amyl nitrite molecule. In this communication the study of the carbanion formation has been extended to the α-halogenated acetophenones through the synthesis of α-bromo—α-isonitroso acetophenones (4) and α-chloro—α-isonitroso acetophenones (3). Both these types of compounds are compared structurally by the study of their reactions (i) oxidative fission (ii) and with dilute sulphuric acid. The reaction studied analytically is nitrosation which may be taken to be a particular case of acylation in the case of α-bromo acetophenones. α-Chloro—α-isonitroso acetophenones prepared for this purpose to see the structure similarties with the corresponding bromo componds.

EXPERIMENTAL

The synthesis of α-chloro—α-isonitroso acetophenone and α-chloro—α-isonitroso (p-methoxy, p-methyl and p-chloro) acetophenones was carried out according to the general methods given by Levin and Hartung (3) and a method by Singhal and Bokadia (4).

The synthesis of α-bromo—α-isonitroso acetophenone and α-bromo—α-isonitroso (p-methoxy, p-chloro and p-bromo) acetophenones have been described by Singhal and Bokadia (4).

The compounds were characterized and their melting points are given in table given below. These compounds were subjected to oxidative fission with Kiliani's-dichromate mixture and heated with dilute sulphuric acid. The acids obtained are recorded in table given below.

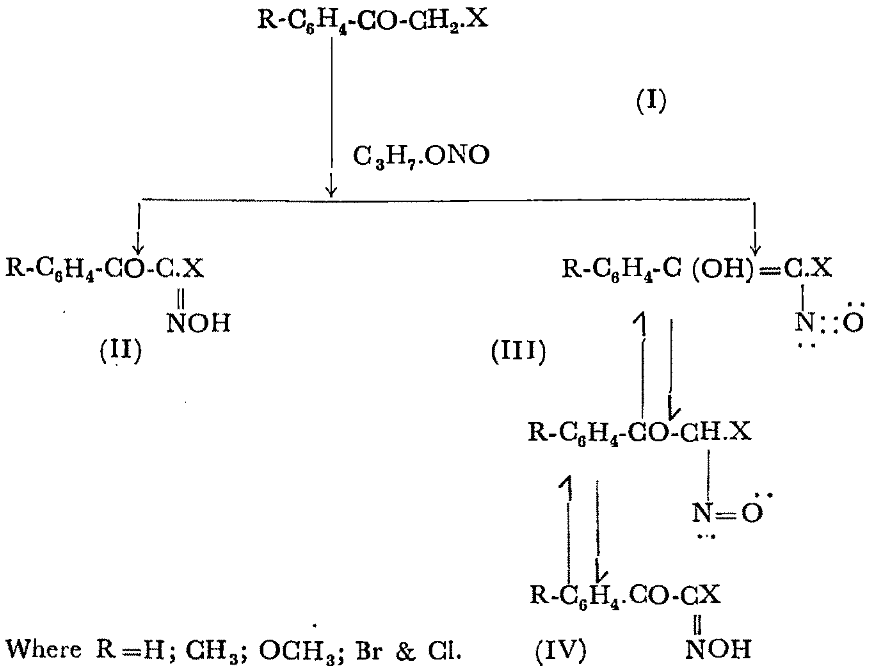
Table. 1

Sl. No.	Name and structure of compound		Products of oxidative fission and of dilute sulphuric acid.	
	Chloro compounds	Bromo compounds.	Name and structure	Melting points & Eq. wts.
1.	$C_6H_5\text{-}CO\text{-}CCl=NOH$ α-chloro—α-isonitroso acetophenone. M. P. 133°C.	$C_6H_5\text{-}CO\text{-}CBr=NOH$ α-bromo—α-isonitroso acetophenone. M. P. 137°C.	C_6H_5COOH Benzoic acid.	120°C. Eq. Wt. Obs:123.1g. Cal; 122.g
2.	$\underset{\underset{NOH}{\Vert}}{OCH_3\text{-}C_6H_4\text{-}CO\text{-}CCl}$ α-chloro—α-isonitroso-p-methoxy acetophenone. M. P. 142°C.	$\underset{\underset{NOH}{\Vert}}{OCH_3\text{-}C_6H_4\text{-}CO\text{-}CBr}$ α-bromo—α-isonitroso-p-methoxy acetophenone. M. P. 139°C.	$OCH_3\text{-}C_6H_4\ COOH$ p-methoxy benzoic acid.	182°C. Eq. Wt. Obs:154.5g. Cal;152.g.
3.	$\underset{\underset{NOH}{\Vert}}{Cl\text{-}C_6H_4\text{-}CO\text{-}CCl}$ α-chloro—α-isonitroso-p-chloro acetophenone. M. P. 124°C.	$\underset{\underset{NOH}{\Vert}}{Cl\text{-}C_6H_4\text{-}CO\text{-}CBr}$ α-bromo—α-isonitroso-p-chloro acctophenone. M. P. 140°C.	$Cl\text{-}C_6H_4\ COOH$ P-chloro benzoic acid	235°C. Eq. Wt. Obs:156.9.g. Cal:157.g.
4.		$\underset{\underset{NOH}{\Vert}}{Br\text{-}C_6H_4\text{-}CO\text{-}CBr}$ α-bromo—α-isonitroso p-bromo acetophenone. M. P. 141°C.	$Br\text{-}C_6H_4\ COOH$ p-bromo benzoic acid.	250°C. Eq. Wt. Obs: 200g Cal: 201.g.
5.	$\underset{\underset{NOH}{\Vert}}{CH_3\text{-}C_6H_4\text{-}CO\text{-}CCl}$ α-chloro—α-isonitroso-p-methyl acetophenone. M. P. 130°C.		$CH_3\text{-}C_6H_4\ COOH$ p-methyl benzoic acid.	178°C. Eq. Wt. Obs:135.1.g. Cal: 136.g.

DISCUSSION

The carbanion formation in unsymmetrical ketones and in halogen esters has been observed in their conversion to hydroxymethylene compounds by several workers (5, 1).

In the present paper the authors have investigated the carbanion formation through nitrosation. The reaction of nitrosation of ∝-halogenated acetophenones proceeds through the intermediate formation of carbanion. It may be represented as :



Where R=H; CH_3; OCH_3; Br & Cl.
X=Br or Cl.

Thus the essential feature of isopropyl nitrite is that it cannot form carbanion needed for the reaction at (III). Hence it can only behave as an acceptor at this stage in the reaction. This behaviour results only in the nitrosation of ketones. In the nitrosation of phenacyl chlorides or (bromides) in the presence of hydrogen chloride there are three competing reactions, (i) nitrosation of ∝-halogenated acetophenones, (ii) self condensation of halogen acetophenones themselves and (iii) Wurtz type of reaction (6). The nitrosation products were obtained in sufficient yield. By all these reactions, the nitrosation seems to be most prominent.

Thus by the action of isopropyl nitrite two isomeric forms should be formed. Actually, however, only one form is obtained. The structure of this form can be arrived at by studying the acid isolated after oxidative fission by potassium dichromate. Thus in the case of ∝-halogenated acetophenone it has been shown that nitrosation takes place at methylene group.

CONCLUSION

The carbanion formation in α-halogenated acetophenones, through synthesis and reactions of α-chloro or α-bromo—α-isonitroso acetophenones, has been studied. Study of nitrosation reveals that in case of α-halogenated acetophenones the carbanion formation takes place at methylene group.

ACKNOWLEDGEMENT

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DAMPING OFF OF CUCURBITACEOUS VEGETABLES AND ITS CONTROL

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INTRODUCTION

Damping off of cucurbits has been observed to occur at Kanpur and its neighbouring villages for the last several years, specially during rainy season. Haenseler (1930) recorded that the decay of vegetable seeds was due to *Pythium ultimum* and *Corticium solani* causing damping off. He also observed post-emergence damping off of cucumber seedlings and employed formaldehyde for controlling it. Doran (1928) recorded damping off of cucumbers, sugar beets, and lettuce but he did not specify the inciting organism. Later in 1932 he found that pyroligneous acid was a better soil disinfectant than formaldehyde and vinegar. In 1934 Osmun isolated *Pythium* sp. from damped off cucumber seedlings but sometimes *Rhizoctonia* was also found associated with the disease. In 1934 Bewley reported damping off in glass-house crops, including cucumber but it seemed to be a physiological disease. In the same year Yu also reported that cucumber suffered heavily from damping off incited by *Pythium* sp. Subsequently, he (1940, 1945) identified the inciting organism as *Pythium aphanidermatum* and studied it extensively. Takimoto (1941) reported damping off and fruit rot of cucumber and named the inciting fungus as *P. cucurbitacearum*. He tried to control the disease with fungicides like, formale-dehyde, Ceresan, and Cuprocide. In 1952 Linnasalmi reported damping off of herbaceous plants including cucumber and described *P. debaryanum, P. ultimum,* and *Corticium solani* as the inciting organisms. He found that seed treatment was not effective against *C. solani*. Recently, Tamayo and Orilo (1957) found Spergon to be highly effective against pre-emergence damping off of vegetables. Cucumber was particularly benefited by seed treatment. However, none of the fungicides tested gave satisfactory control of post-emergence damping off incited by *P. debaryanum* and *C. solani*. Considering the importance of the disease, the present work was undertaken during 1954-55 to study the etiology, relationship between the disease and environmental factors, and to formulate suitable control measures.

MATERIALS AND METHODS

Damped off seeldings of *Cucumis sativus* Linn. (Cucumber), *Momardica charantia* Linn. (Bitter gourd), *Luffa cylindrica* Roem. (Sponge gourd), and

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Lagenaria siceraria Standl. (Bottle gourd), and *Cucurbita pepo* Linn. (Pumpkin) were collected and isolations were made from them.

Separate cultures of isolates from different cucurbits were maintained and subculturing of these isolates was continuously done once a week during Monsoon and once in every 10 days during winter season to keep them in actively growing stage.

For zoospore studies the procedure used by Cotner (1930) was followed. The zoospores were mounted on a clean slide and the slide was then exposed to the vapours of 1% Osmic Acid. After 4-5 minutes' exposure it was dried for nearly 2 hours. After drying the smear was stained with Carbol fuchsin.

The soil used in these studies was loam soil which, after being adequately manured, was autoclaved for about 2 hours at 15 lbs. pressure. For inoculation, the fungus culture (about 5% by volume) was thoroughly mixed with the autoclaved soil.

SYMPTOMS

The symptoms of the disease can be divided in pre-and post-emergence phases. In severe cases of pre-emergence damping off, blank patches appear in the seed beds and can be mistaken to be due to poor quality of the seeds. But on digging, the seeds and sprouts are found to be affected with the disease. The affected seeds produce a foul smell and have water-soaked spots on them. Their coat is soft and they are meshy. Occasionally due to the invasion of the radicle and the plumule of the germinating seeds the sprouts are not allowed to come upto the surface of the soil. Their growth is checked and they are finally killed.

The first indication of the post-emergence damping off is discolouration or appearance of the water-soaked spot on the collar just at the ground level. The discoloured part decays and results in constriction and bending of the seedlings. The lesion grows larger and larger until it encircles the stem and as a result a ring of dead tissues is formed and the seedlings fall on the ground. Growth of such seedlings is arrested and whenever they are pulled out they break at the point of attack. With the gradual increase of infection the primary leaves are affected and turn brown and necrotic. Finally the whole seedling dies and appears like a brown string. In severe cases of the disease, patches in the seed beds are found covered with dead seedlings. Occasionally a cottony growth of the fungus appears on the dead seedlings.

Microscopic examination of the decayed tissues reveals the presence of branched, coenocytic and hyaline hyphae which are both inter-and intra-cellular. In late stages of attack antheridia and oogonia are found in the internal tissues, specially in cortical region.

The tissues of the host are watery and lack firmness. The watery contents of the affected seedlings are turbid and produce unpleasant odour. In the final stages of the disease the tissues die and disintegrate.

EXPERIMENTATION

The isolate obtained from every cucurbit was found to be pathogenic to the particular crop from which it was obtained, as well as, to all the aforementioned cucurbits. These isolates were invariably *Pythium* sp. and were identical. In further studies hyphal tip cultures of cucumber isolates were used.

MORPHOLOGY OF THE FUNGUS

The mycelium consists of copiously branched, hyaline, and coenocytic hyphae which exhibit an abundant aerial development and are full of granular protoplasm. Their width varies from 3 to 6 μ, with an average diameter of 4.8μ. Sporangia are found abundantly when the mycelium is placed in water. Their production is enhanced if boiled ants or flies are added to the water culture and also when temperature and humidity are high. Sporangia are lobulate, branched or unbranched and inflated . and grow as continuous irregular swellings on the hyphae. Their size is 200 to 400 $\mu \times 6$ to 20 μ. From the sporangial tips short emission tubes are given out which begin to form evanescent vesicles. The vesicles are more or less spherical and vary from 30 to 50 μ in diameter. The formation of zoospores occurs in the vesicle. The number of zoospores produced in a vesicle varies from 10 to 20. They are kidney-shaped and biflagellate and measure from 10 to 13 $\mu \times 7$ to 9μ in active stage and about 6 to 8 μ in diameter in encysted stage. They are monoplanetic and germinate by formation of one germ tube and rarely by formation of two tubes.

In 3 to 5 days old cultures ovoid to spherical oogonia arise terminally on short lateral stalks, less often they are intercalary borne on unmodified hyphae. They are thin-walled, smooth and range in diameter from 18 to 26μ. At maturity the protoplasm of the oogonia differentiates into the oosphere and the periplasm. Soon after the appearance of the oogonial initial, the antheridia begin to develop. They are mostly intercalary and sometimes apical and vary in shape from clavate to globose. They measure 9 to 14×6 to 10μ. Usually the antheridia are monoclinous and only rarely they are diclinous. Generally one antheridium, exceptionally two, may be seen appressed against one oogonium but only one antheridium takes part in fertilization. The antheridium produces a conjugation tube which enters the oogonium laterally or terminally. Through this conjugation tube fertilization takes place and the oosphere then becomes oospore. The oospores are thick-walled, hyaline, smooth, and spherical to subspherical. They measure from 13 to 25 μ with an average of 18 to 20 μ and are aplerotic. The oospores germinate by producing a germ tube and not by zoospores.

On the basis of the above studies the fungus has been identified as *Pythium aphanidermatum* (Edson) Fitzpatrick.

Growth of the Fungus on Different Media.

About 12 cc. of various media, as given in the Table I, were poured in each Petri plate of about 150 mm. diameter. The plates were inouculated with the fungus inoculum in standard agar discs of about 4 mm. diameter and the linear measurements of the fungal colonies were taken after every 10 hours of inoculation and the results are given in the Table I.

Table I

Relative linear growth of the fungus on different media

Media	Average* diameter of the fungal colony in mm. after					
	10 hrs.	20 hrs.	30 hrs.	40 hrs.	50 hrs.	60 hrs.
Maize Meal Agar	9	45	75	Complete	Complete	Complete
Oat Meal Agar	7	35	66	135	-do-	-do-
Potato Dextrose Agar	6	28	60	126	-do-	-do-
Elliot's Agar	4	22	46	72	110	-do-
Richard's Agar	4	16	39	62	95	nearly complete

From the results in the previous table it is evident that the growth of the fungus is best on maize meal agar, followed by the growth on oat meal agar, potato dextrose agar. The growth of the fungus in synthetic media like Richard's and Elliot's Agar is very poor.

Growth of the Fungus at Different Temperatures.

About 9 cc. of the sterilized oat meal agar medium was poured in each Petri plate of about 100 mm. diameter. The plates were inoculated with equal amount of fungus in 4 mm. agar discs and were placed at controlled temperatures in the incubators. The growth of the fungus was measured after a day and the results are given in the Table II.

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* Average value of six replications.

Table II

Effect of Temperature on the linear growth af the Fungus

Replication	Diameter of the fungal colonies in mm. at :				
	18°C.	23°C.	28°C.	33°C.	38°C.
1	20	29	36	38	36
2	19	29	37	38	34
3	18	28	36	39	42
4	22	30	36	37	34
5	21	31	37	38	33
6	20	29	35	38	34
Average	20	29	36	38	35

It is evident from the data given in the previous table that the growth of the fungus is profuse in the range of 28° to 38° C. and scenty at 18° and 23° C. It is concluded therefore, that the optimum temperature range for the growth of the fungus is between 28° and 38° C. and below 28° C. the growth is retarded.

FACTORS AFFECTING INCIDENCE OF THE DISEASE

Experiments were conducted to find out the effect of soil moisture, thick sowing, and age of the host plants on the incidence of the disease.

Soil Moisture : Water holding capacity (W. H. C.) of the soil was determined with the help of Hilgard's apparatus and the soil was divided into six lots according to the moisture (W. H. C.) adjustment. Six replications were maintained in each case. After adjusting moisture the inoculated and the uninoculated soils were filled in pots and seeds were sown. Weight of the individual pots was taken twice a day and the loss was recouped by addition of water and the results are given in the Table III.

Table III

Relationship between sail moisture content and damping off of Cucumber

Soil Moisture	%Post-emergence damping off in		%Pre-emergence damping off in	
	Uninoculated Soil	Inoculated Soil	Uninoculated Soil	Inoculated Soil
20	0	0	0	10
40	0	0	0	10
60	0	33	0	20
80	0	50	0	0
90	0	50	0	0
95	All dead	All dead	...	...

From the previous data it is evident that post-emergence damping off is very severe at 80 and 90% moisture contents, whereas pre-emergence damping off is at its height of severity at 60% moisture content. The total loss is almost constant at a range from 60 to 90% moisture content. The death of seedlings at 95% moisture of W. H. C. is not due to damping off alone because the seedlings grown in uninoculated soil also died. It is probably, because of the inhibition of the physiological activities of the roots due to exclusion of the air from the soil which led them to death.

Thick Sowing : With a view to determine the relationship between thickness of sowing and the incidence of the disease, two series of 4" pots were taken. In one series inoculated and in the other uninoculated soil was filled. Different number of seeds was sown in each pot and the results are given in Table IV.

Table IV

Relationship between thin or thick sowing and post-emergence damping off of Cucumber

Number of seeds per pot	Per cent* post-emergence damping off :	
	Uninoculated Soil	Inoculated soil
2	0	40
5	0	46
10	0	61
15	0	77
20	0	90

From the results in the preceding table it is evident that as the number of seeds per pot increases the per cent death of the seedlings also increases. The increase in damping off in the cases of thick sowing is probably due to two main reasons. Firstly, thick sowing promotes delicate and thin-walled tissues which are particularly liable to the disease, secondly over-crowding of the seedlings by preventing light and air circulation increases humidity which is conducive for infection.

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* Average of a total of 30 seedlings.

Age of the Suscept : In order to know whether the age of the suscept has got any relationship with the disease, cucumber seedlings of different ages were inoculated at the collar after giving a slight scratch. The results are presented in the Table V.

Table V

Relationship between the age of the cucumber seedlings and the post-emergence damping off

Age of the seedlings in days	No. of seedlings inoculated	No. of seedlings infected	%infection
3	10	9	90
5	10	8	80
8	10	5	50
10	10	3	30
13	10	1	10
16	10	1	10
18	10	0	0

The data in the previous table show that 3 to 5 days old seedlings are highly susceptible to the disease. After about 13 days majority of the seedlings become hardy enough to outgrow the fungus, resulting in a very low incidence of the disease. Usually only those seedlings which are tender and have not developed secondary leaves are attacked.

CONTROL

Since it is known that *Pythium* spp. perpetuate in the soil, attempts were made either to destroy the fungus in the soil or to protect seeds from its invasion. A number of statistically laid out experiments were performed with several fungicides. In one set of experiments, seeds were treated with fungicides and were sown in inoculated, as well as, in uninoculated soil. In the other set of experiments the inoculated, as well as, uninoculated soil was treated with formaline and after 24 hours of treatment seeds were sown. Controls were maintained for each set and the results are presented in the Tables VI and VII.

Table—VI

Relative efficacy of the different fungicides for the control of damping-off of cucumber.

Fungicides		% Germination	% healthy seedlings	% post emergence damping-off	% pre-emergence damping-off	Total % of damping-off*
Seed Treatment						
1. Ceresan	S	58	58	0	0	0
	I	59	50	9	0	9
2. Ceresan	S	75	75	0	0	0
	I	72	65	7	3	10
1. Agrosan G	S	75	75	0	0	0
	I	69	55	14	6	20
2. Agrosan G	S	80	80	0	0	0
	I	70	55	15	10	25
1. Spergon	S	80	80	0	0	0
	I	70	55	15	10	25
2. Spergon	S	80	80	0	0	0
	I	67	50	17	13	30
1. Phygon	S	60	60	0	0	0
	I	59	50	9	1	10
2. Phygon	S	80	80	0	0	0
	I	74	60	14	6	20
1. Copper carbonate	S	75	75	0	0	0
	I	70	60	10	5	15
2. Copper carbonate	S	80	80	0	0	0
	I	74	60	14	6	20
1. Cuprous oxide	S	60	60	0	0	0
	I	57	50	7	3	10
2. Cuprous oxide	S	75	75	0	0	0
	I	69	60	9	6	15
Soil Treatment						
1. Formaline	S	60	60	0	0	0
	I	59	50	9	1	10
2. Formaline	S	75	75	0	0	0
	I	74	60	14	1	15

1	2	3	4	5	6
		Control			
St. Soil + Untreated seeds	84	84	0	0	0
Inf. Soil + Untreated seeds	57	40	17	27	44

1 : 3% concentration (by weight) of fungicides
2 : 2% concentration (by weight) of fungicides
S : Sterilized soil I : Infested soil
* Critical difference=1·45

Table—VII

Relative efficacy of different fungicides for the control of damping-off of sponge gourd

Fungicides		% Germination.	% healthy seedlings	% of post emergence damping-off	% pre-emergence damping-off	Total % of damping-off.*
			Seed Treatment			
1. Ceresan	S	48	48	0	0	0
	I	51	40	11	0	11
2. Ceresan	S	80	80	0	0	0
	I	74	60	14	6	20
1. Agrosan G	S	76	76	0	0	0
	I	70	55	15	6	21
2. Agrosan G	S	80	80	0	0	0
	I	67	50	17	13	30
1. Spergon	S	75	75	0		0
	I	70	55	15	5	20
2. Spergon	S	80	80	0	0	0
	I	67	50	17	13	30
1. Phygon	S	60	60	0	0	0
	I	56	45	11	4	15
2. Phygon	S	75	75	0	0	0
	I	66	50	16	9	25

1		2	3	4	5	6
1. Copper carbonate	S	75	75	0	0	0
	I	71	55	16	4	20
2. Copper carbonate	S	80	80	0	0	0
	I	65	50	15	15	30
1. Cuprous oxide	S	55	55	0	0	0
	I	51	40	11	4	15
2. Cuprous oxide	S	75	75	0	0	0
	I	74	60	14	15	29
Soil Treatment						
1. Formaline	S	65	65	0	0	0
	I	59	50	9	6	15
2. Formaline	S	80	80	0	0	0
	I	70	55	15	10	25
Control						
St. Soil + Untreated seeds		86	86	0	0	0
Inf. Soil + Untreated seeds		50	45	5	36	41

1 : 3% concentration (by weight) of fungicides
2 : 2% concentration (by weight) of fungicides
S : Sterilized soil, I : Infested soil
* Critical difference = 1·75

The statistical analyses of the data in Tables VI and VII show that the results are significant at 1% level, meaning thereby that by using fungicides damping off is significantly reduced. The results in the above-mentioned tables also show that Ceresan is most effective in controlling damping off of cucurbits. Cuprocide, formalin, and Phygon are also quite effective in checking the disease. Although several other fungicides also controlled the disease, their efficiency is relatively low. In this connection, it should also be noted that all the fungicides when applied in high concentrations have adverse effects on the germination of the seeds but the effects of Ceresan and Cuprocide are very pronounced. A similar phenomenon of hampered germination of seeds by the application of the overdoses of Ceresan was reported by Krietlow *et., al.* (1950).

SUMMARY

The disease occurs in pre-and post-emergence phases.

Pythium aphanidermatum (Eds.) Fitz., is found to incite the disease. The fungus grows well on maize and oat meal agars but not on Elliot's and Richard's agar media. Optimum temperature range for the growth of the fungus in culture is from 28⁰ to 38⁰ C.

Three to five days old seedlings are highly susceptible to the disease, which is also favoured by overcrowding of the seedlings, and by high soil moisture content (60 to 90% of W. H. C.).

Seed treatment with Ceresan, Cuprocide, and Phygon gave good results in controlling the disease but when applied in high doses they hampered seed germination. Soil treatment with formalin also checked the disease to a great extent.

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* Quoted from their abstracts in the *Review of Applied Mycology*.

STUDIES ON A LUXURIANT FORM OF TEOSINTE AND ITS HYBRIDS WITH MAIZE

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Euchlaena mexicana Schrad. (*Zea mexicana*, Reeves and Mangelsdorf, 1942) commonly called as teosinte is a native of Central America and grows widely distributed as a weed in the cultivated fields and waste lands from North Central Mexico to Honduras (Weatherwax, 1955). Hitchcock (1950) also considers teosinte as essentially a wild species, though occasionally cultivated for green forage in the southern states of U. S. A. Collins (1925) does not regard teosinte as strictly a wild plant because a clear evidence is lacking for its existence in nature outside the cultivated regions (see also Arber, 1934).

In Indian floras teosinte is described only by Haines (1924). It appears that it was introduced in the states of Bihar and Orissa from some place in Europe. Haines (1924) mentions it being grown as a fodder crop particularly for horses by Europeans. Richharia (1957) mentions *Euchlaena mexicana* in the list of fodder crops found in India. In Bombay, Kumar (1939) is reported to have made selections of a few vigorous fodder types from the cross *Euchlaena mexicana* x *Zea mays*.

According to Haines (1924) teosinte found in Bihar and Orissa is *Euchlaena mexicana* Schrad. var. *Luxurians* (Syn. *Reana luxurians* Brogn.). He describes it as a large succulent grass, 3-6 feet high with leaves 2-3 inches wide. The teosinte grown in U. S. A. has been described by Hitchcock (1950) as tall annual grass resembling maize; culms branching at base, usually 2-3 m tall or sometimes even 5 m tall with leaf blades as much as 8 cm. wide.

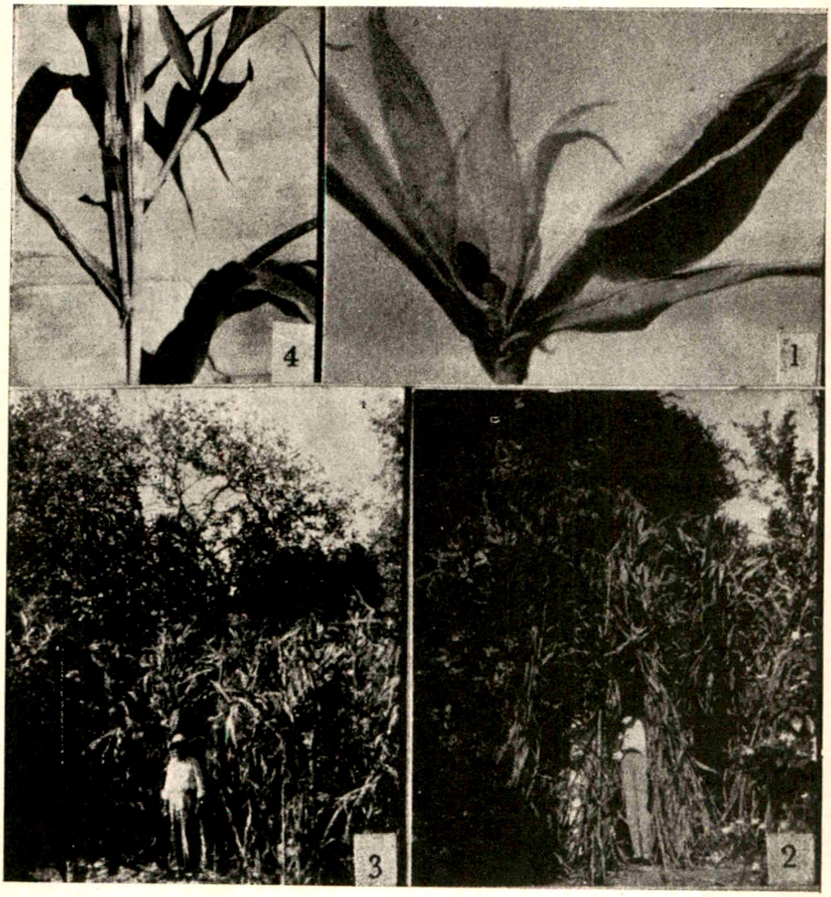
The reproductive organs of teosinte have been described among others by Mangelsdorf and Reeves (1939) and Weatherwax (1955). Some information on the vegetative structures of teosinte is available in the articles by Rogers (1950) and Reeves (1953). Rogers (1950) has described the inheritance of photoperiodic response and tillering in maize-teosinte hybrids and in another article he has described the inheritance of some important inflorescence characters (Rogers, 1950 a). A difference in the number of tillers is one of the main characteristics distinguishing maize from most varieties of teosinte. Even different varieties of teosinte may have significant differences in the number of tillers per plant. Rogers (1950) has tabulated the mean number of tillers and mean number of days to anthesis in three varieties of Mexican and three varieties of Guatemalan teosinte and their hybrids with maize. He concludes that the number of tillers is largely controlled by genes on the same chromosomes (1, 2 and 7) of the different varieties indicating a similar source of genes for this character. However, these genes are much more effective in the Guatemalan than in the Mexican teosintes, as their effect in the latter group of varieties has apparently been weakened by the introgression of the maize germplasm.

In October, 1954 the senior author observed a vigorous plant in the Botanical gardens of this college, which looked like maize except for large number of tillers and darker green colour. When it came to bloom it was identified as *Euchlaena mexicana* Schrad. or *Zea mexicana* (Reeves and Mangelsdorf, 1942). Since this teosinte was different from all other teosintes on record in height and vigour, it was thought desirable to pursue studies on this teosinte further. It produced enough seeds on typical teosinte like ears (Fig. 1) which were collected and all the observations reported in the present paper are based on the progeny of this plant or its hybrid progenies with maize. For convenience this teosinte will be referred to as B. R. C. teosinte in the text.

The first set of teosinte seeds obtained from the parent plant was sown in pots on eleventh March, 1955. They started germinating after six days and the percentage of germination was 93.3. It may be added that only fully grown and mature seeds were sown while all the smaller grains slightly greenish in colour which did not appear to be fully mature were sorted out. Eight days old seedlings were then transplanted in the pots. All the transplanted seedlings fared very well and there was no mortality. The seedlings differed in the pigmentation of the basal part of the stem. In this population of 56 seedlings, 50 were pigmented while only six were green.

The vegetative growth of the plant continued for over six months and on the whole it was very luxuriant (Figs. 2 and 3). The mean height of the plant was 14.55 feet (some plants being as tall as 19 feet), with a mean number of 31.5 nodes and internodes, and 9.06 tillers per plant with several secondary branches (Fig. 4). The vegetative growth was so luxuriant and the plants grew so tall that the stems could not keep erect and had to be tied with bamboo poles to save them from lodging (Fig. 2). The entire plant presented a cup or bowl shaped appearance with the tillers in a culm bent outward at the basal part for some distance and then straightening upward.

In all respects these plants were either as vigorous or even more so than the single parent plant from which this progeny was raised. Since there was no maize in the garden in 1954 or within an area of about half a mile, all the seeds obtained from the parent teosinte plant must have been



Figs. 1—4. Fig 1. Female inflorescence of teosinte. Figs. 2 and 3. Teosinte crop raised from seeds from a single plant. Fig 4. A part of plant showing secondary branches.

produced as a result of selfing. It is evident, therefore, that inbreeding, at least for one generation, did not have any ill effect on the growth and vigour of the progeny.

The male inflorescence (Fig. 5) first appeared on the main shoot on 14th September, while the silks of the pistillate spikes appeared on 1st October. Thus, just like maize, these plants were also typically protandrous. Similarly all tillers were also protandrous. But the secondary branches borne either on the main stem or on the tillers were protogynous because here the female spikes matured earlier than the male flowers on the tassel.

There are several types of teosintes that are now collected and studied in U. S. A. They are classified in two groups according to their probable place of origin *i.e.*, Mexican and Guatemalan. They differ from each other in several features like number of tillers per plant, mean number of days to anthesis, in the homology of their chromosomes with maize and so on. It would be interesting to compare the B. R. C. teosinte with some of these Guatemalan and Mexican teosintes. The data on mean number of tillers per plant and mean number of days to anthesis in three Mexican and three Guatemalan varieties from Rogers (1950) are presented in the Table I and the observations on B. R. C. teosinte made by us are placed in this table for comparison. It is interesting that in both these characters the B. R. C. teosinte comes closest to Jutiapa teosinte which is one of the South Guatemalan teosintes.

TABLE I.

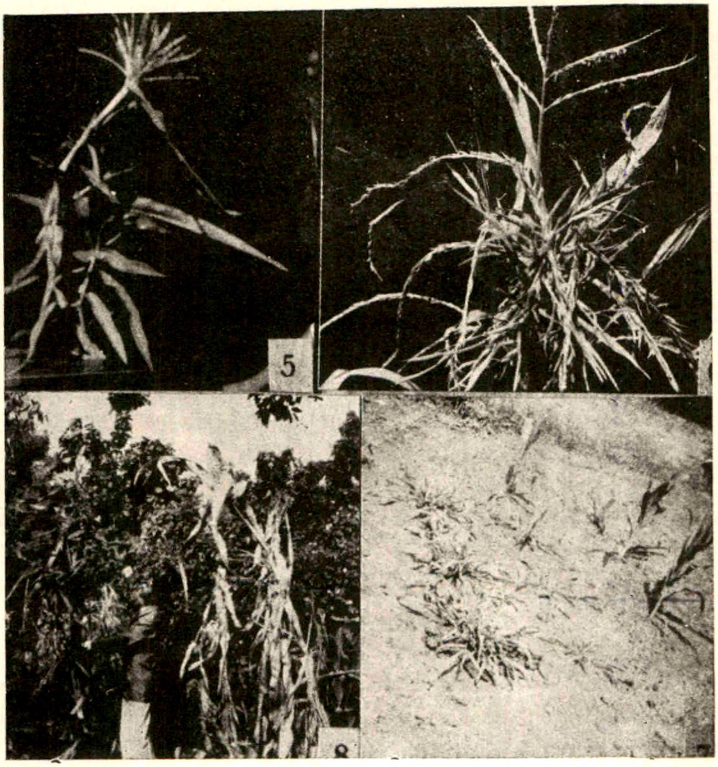
Variety of Teosinte		Mean number of tillers	Mean number of days to anthesis
Mexican	Nobogame	5.38	110.4
	Durango	4.88	137.5
	Chalco	1.10	146.0
Guatemalan	El Valle	14.14	199.6
	Huixta	10.92	207.0
	Jutiapa	8.50	206.2
	B. R. C.	9.06	205.0

Abnormalities :

Another batch of teosinte seeds was sown in November, 1955 to see how it would fare in the winter conditions. The plants in this season were on the whole very dwarf as compared with teosinte grown during rainy season. Majority of the plants grew only 1½—2 feet tall. There were, however, a few plants which were terribly dwarf and attained a height of 6—9 inches only. These were more dark and green than the taller ones. The leaf blade bent at almost right angles with the auricle, whereas in other plants it grew obliquely upward and only the upper part of the leaf blade reflexed outward.

The reproductive phase started early in these plants as compared to the rainy season crop. The staminate inflorescence appeared in the first week of March after four months of vegetative growth period. Most of the dwarf plants, falling in the 6—9 inches group, showed some abnormality in the terminal inflorescence. Mostly it was an unbranched spike with female flowers in the middle portion of the spike while the male flowers occurring both at the basal, as well as the upper part of the inflorescence. The taller plants, falling in the 1½—2 feet group, had more or less normal tassels with fewer abnormalities. The female spikes were almost normal in all the plants. One dwarf plant was characteristically female with the terminal, as well as axillary inflorescences bearing only female flowers on typically teosinte like ears.

It is rather interesting to note that the same stock of seeds obtained from one teosinte plant was used in both the sowings to raise the rainy season and the winter season teosinte. Whereas we do not remember to have seen a single abnormal tassel in the rainy season teosinte, there was a very high frequency of abnormalities in the male inflorescences in the winter months. It is remarkable that this is also true for American varieties of maize grown in winter under north Indian condition. Secondly the terminal inflorescence



Figs. 5—8. Fig. 5. A part of plant showing male inflorescence. Fig. 6. The male inflorescence of teosinte changing into bulbil. Fig. 7. Bulbils planted in soil growing independently. Fig. 8. F_1 hybrids of Maize x Teosinte.

is more amenable to the abnormalities than the axillary inflorescence. It is, however, clear that the normal growth of teosinte takes place only during rains under north Indian conditions and our comparisons of B. R. C. teosinte with American varieties of teosinte have been made on the basis of data collected on the rainy season teosinte only.

Vegetative reproduction.

An interesting form of vegetative reproduction has been observed in B. R. C. teosinte as well as its hybrids with maize. In such cases the tassel is converted into a big bulbil (Fig. 6). Close observations have been made on the metamorphosis of the tassel into vegetative structure or bulbil. The early development of the tassel is normal. Anthers develop regularly in the florets and reach up to microspore stage. Later on the glumes of some of the florets in several spikes start growing and soon become leafy. This leafy growth continues both upward as well as downward and the central spikes as well as the florets on the lateral spikes develop into big leafy structures. All the spikes of an inflorescence are not always necessarily effected and changed into leafy structures. In Fig. 6 the florets in the upper part of the inflorescence show anthers hanging out while the lower spikes have changed into bulbils. Such bulbils may be formed on the main shoot, on the tillers, as well as on the secondary branches on the main stem. In some cases all the tassels on one plant may be transformed into bulbils. In well developed bulbils adventitious roots have been observed to come out but in nature these bulbils were not observed to get detached from the parent plant and start a new offspring. When these bulbils are, however, artificially detached from the mother plant and planted in the soil (Fig. 7) they develop into healthy independent plants. It may be added here that such vegetative tassels or bulbils were observed only in the teosinte or teosinte—maize hybrid progenies that had been sown in the month of February or March and came to bloom in the month of June. It is likely that the cold temperature to which the plants were subjected in early stages of development may be responsible in some way for this effect.

Collins (1909) first reported what he called a case of apogamy in maize, in which the plants actually continued vegetative growth instead of producing reproductive organs for a considerable period of time. Such uncontrolled vegetative growth in maize, as well as teosinte was reported again by Reeves and Stansel (1940). The essential characteristics of such abnormal maize plants were their continued vegetative growth till they became twice as tall as the normal plants. These abnormal plants produced terminally an abnormal tassel or no tassel at all, while in the leaf axils structures like tassels were produced. In teosinte as a rule the entire plant was never affected and this anomaly was restricted to certain branches only. Neither Collins (1909) nor Reeves and Stansel (1940) observed the formation of abnormal tassels on plants showing this type of abnormal growth. Recently Rogers (1950) has reported the formation of vegetative tassels in the segregating population of maize-teosinte hybrids. In such cases vegetative structures develop in place of the normal spikelets of the staminate inflorescence terminating the branches. Rogers (1950) concludes that these plants actually revert back to a vegetative state after a certain degree of floral initiation under certain photoperiodic conditions. Whereas this may be true there are certain significant points which must be mentioned in this connection. Rogers (1950) is quiet about the development of pistillate spikelets in the leaf axils of the plants showing the development of the vegetative tassels. In our material showing the formation of terminal bulbils, normal development of pistillate spikelets has been observed in the leaf-axils. Secondly the metamorphosis into vegetative tassels in our material started only after complete development of the spikelets on the tassel but before their anthesis. Thirdly some tillers of a plant may develop bulbils while others may form normal tassels so that the entire plant is not always necessarily effected by this metamorphosis. Finally even an entire inflorescence may not undergo metamorphosis, so that whereas the lower part of the inflorescence is changed into bulbil the florets in the upper part produce and disperse viable pollens.

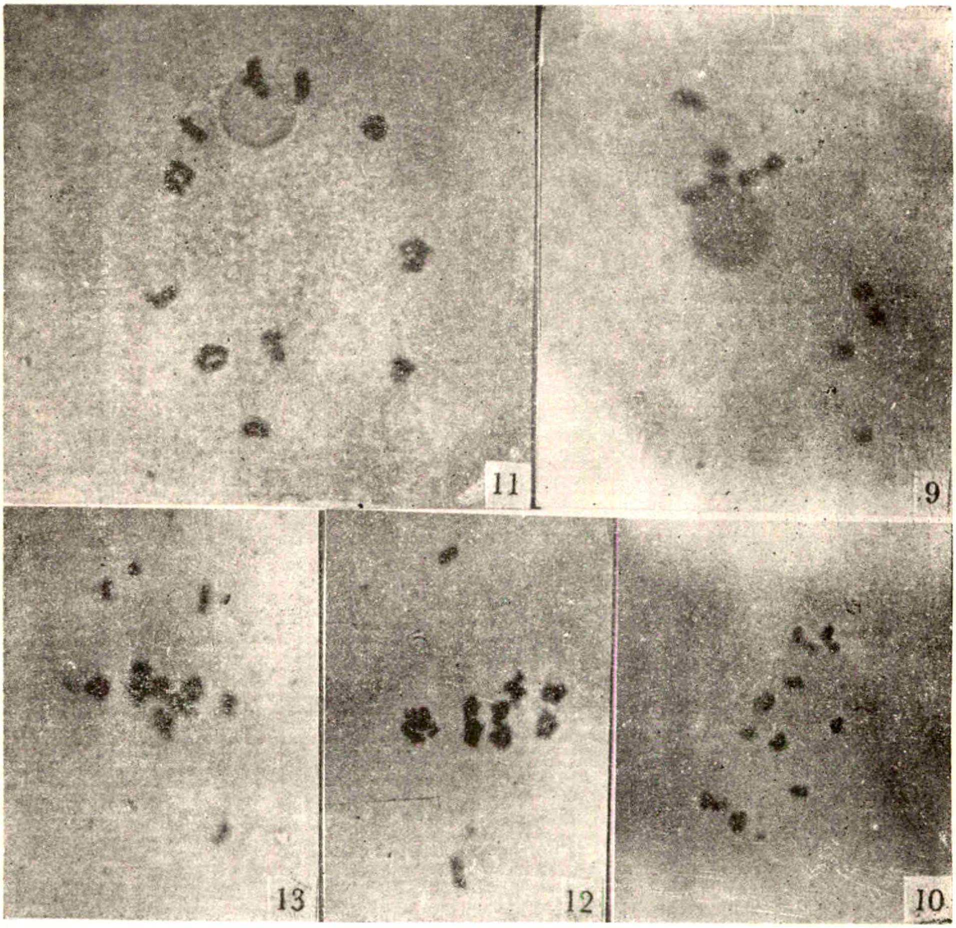
Maize X B. R. C. teosinte hydrids : Just as all other varieties of teosinte, the B.R.C. teosinte could be hybridized with maize quite easily. In October, 1955 reciprocal crosses between Indian maize and B.R.C. teosinte were made. The Fl hybrids were quite vigorous and fertile (Fig. 8). The plants in the F_2 population showed lot of variability, and the mean number of tillers in this population was only 1.35 per plant. Two plants in this F_2 progeny were complete albinos while one plant, which appeared to be a mutant, looked somewhat like a sugarcane x maize seedling. None of these three plants could survive and died long before blooming.

Cytology of B. R. C. teosinte and its hybrids with maize : The diploid chromosome number in B. R. C. teosinte is 20. The chromosomes pair regularly at meiosis and there does not appear to be any serious irregularity throughout the meiotic division and enormous amount of viable pollen grains are formed.

Unfortunately we could not study the cytology of the F_1 hybrids But out of a total population of 102 plants in F_2, 29 plants were examined cytologically at meiosis. Of these 15 plants (approximately 50%) were quite regular, showed perfect pairing with 10 II at diakinesis and metaphase I (Figs. 9, 10) and both the divisions were quite normal. Of the remaining 14 plants classified as irregular, nine plants showed slight irregularities, chiefly at diakinesis and metaphase I. Thus in about 50% of the cells scored in these plants there were 9 II+2 I, (Figs. 11, 12) while in very few cells there were 8 II+4 I. The other five plants were highly irregular and in more than 50% of the cells scored the associations were 8 II+4 I (Fig. 13) and 6 II+8 I.

There were also one or two heteromorphic pairs. One plant showed 20 I at diakinesis and metaphase I.

From earlier studies on the cytology of maize x teosinte hybrids (see Kuwada, 1919 ; Longley, 1924, 1937, 1941 ; Beadle, 1932 ; Arnason, 1936 ; and O'Mara, 1942 ; Mangelsdorf, 1947 ; Rogers, 1950 b) we know that Mexican teosinte x maize hybrids are perfectly regular at meiosis which indicates a closer homology in the chromosomes of the two parents, whereas Florida teosinte x maize hybrids show maximum irregularity at meiosis. It will indicate that B. R. C. teosinte might fall in the group of Florida (Guatemalan) teosinte, since it shows a lot of irregularities when hybridized with maize. A definite conclusion on this aspect will have to wait till we have completed the detailed cytological studies of F_1 hybrids between B.R.C.



Figs. 9—13. Cytology of F_2 hybrids between Maize x Teosinte. Figs. 9 and 10 Normal diakinesis and metaphase respectively with 10 II. Fig. 11. Abnormal diakinesis with 9 II+2 I. Figs. 12 and 13. Abnormal metaphase with 9 II+2 I and 8 II+4 I, respectively. Fig. 11. 2400x ; Figs. 9, 10, 12, 13. 2100x.

teosinte x maize, their pollen condition etc. which are still in progress at our laboratory.

B. R. C. teosinte as a fodder crop :

Teosinte is grown for fodder in southern states of U.S.A. and also Europe. Its hybrids with maize have some promising features as a forage crop in Indian conditions as well (Kumar, 1939; Richharia, 1957). The reasons which point to the adaptability of B. R. C. teosinte as a forage crop are the following. B.R.C. teosinte is the most luxuriant variety which is on record and promises a fairly high yield of fodder per acre. Further we have found that cows have a great liking for teosinte. When maize, Sorghum and teosinte are grown in nearby plots and a cow manages to get in there, invariably she has left maize and Sorghum untouched while preferred teosinte and consumed it. The pith of B.R.C. teosinte is more sweet and soft than that of Sorghum and more suitable to be used as pith to hold the material while cutting hand sections. In our laboratory for several years now we have been using teosinte pith instead of the conventional Sorghum pith.

The handicaps with teosinte to be used on a large scale for fodder crop may be its water requirements and probably long period of growth. But when teosinte has to be used for green fodder it would not be necessary to let it remain for long in the field. However, for the seed purposes it will have to be left in the field for a fairly long period.

The Animal Husbandry and Dairying department of this college is carrying out the nutritional trials on teosinte as a fodder to cows and buffaloes. If it meets all the necessary requirements and is found satisfactory, further attempts shall be made to convert teosinte into a regular fodder crop.

SUMMARY

A variety of teosinte, named as B.R.C teosinte, developed from a single plant found growing in the Botanical Garden of this college, has been described. This teosinte is very luxuriant in vegetative growth, with a mean height of 14.55 feet, 9.06 tillers per plant and 31.5 nodes and internodes per tiller. It hybridizes easily with maize, but the hybrids show a lot of irregularity at meiosis in the form of univalents and heteromorphic pairs. In the F_2 population of maize x teosinte hybrids two plants were complete albinos and one plant looked like a sugarcane x maize seedling. None of these three plants however survived to reach maturity. In teosinte, as well as its hybrids with maize sown in February/March and blooming in June, the staminate inflorescences develop into vegetative tassels or bulbils quite frequently. These when planted in soil produce new offsprings. The possibilities of utilization of B.R.C. teosinte as a fodder crop have been discussed.

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STREAMING PAST A CYLINDER WHOSE SECTION IS BOUNDED BY TWO CIRCLES INTERSECTING ORTHOGONALLY—IRROTATIONAL MOTION AND BOUNDARY LAYER

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1. Introduction

Milne Thomson [1] has given the complex potential for flow past a cylinder whose cross section consists of two equal circular segments on opposite sides of a common base, the direction of the undisturbed stream being perpendicular to the line of centres. In this paper complex potential has been obtained for flow past a cylinder whose cross section consists of two circular segments on opposite sides of a common base such that the boundary arcs cut each other orthogonally without ony restriction on the radii of the circles. The direction of the undisturbed stream makes any angle with the line of centres. Position of stability has been investigated.

Assuming a fluid of small viscosity, motion in a part of the laminar boundary layer round the cylinder has been calculated by the method of Blasius. Meksyn's method [2] has been adopted to calculate the point of separation.

2. Equations of cross section of the cylinder and complex Potential of the flow.

Taking xy plane perp. to the generators of the cylinder, let its cross section be bounded by the circles

$$x^2+y^2=1 \qquad \ldots(1)$$

and $(x-b)^2+y^2=b^2-1$, $\quad b>1$

or $x^2+y^2-2bx+1=0 \qquad \ldots(2)$

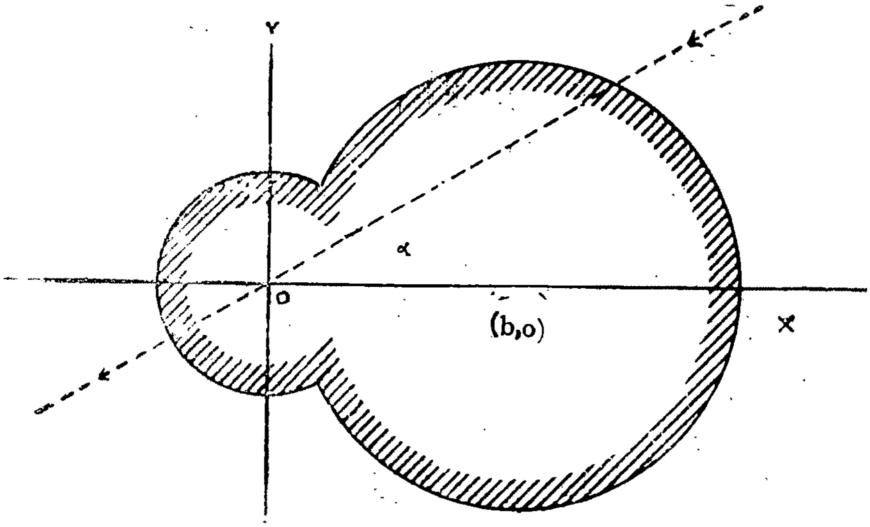

Fig. 1

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For the sake of brevity, we shall refer to a cylinder by referring to its cross section only.

Let us first derive the complex potential for the circle (2) fixed in a stream flowing at an angle α with the x-axis.

The complex potential for a circle $x^2+y^2=a^2$ when the stream is flowing with velocity U at an angle α with x-axis is given by

$$f\,(z)=Uze^{-i\alpha}+U\,\frac{a^2\,e^{i\alpha}}{z} \qquad \ldots(3)$$

Hence by changing the origin, the complex potential due to the circle (2) is seen to be

$$\mathrm{F}\,(z)=U(z\text{-}b)\,e^{-i\alpha}+\frac{U(b^2-1)e^{i\alpha}}{(z-b)} \qquad \ldots(4)$$

Now to obtain the complex potential due to the circles (1) and (2), we shall apply Levin's Extension [3] of Milne Thomson's circle Theorem, which may be enunciated as follows :—

Let $f\,(z)$ be the complex potential of a two dimensional irrotational flow of an inviscid liquid. Let the singularities of $f\,(z)$ be at a distance greater than unity from the origin, and let the rigid boundaries be such that they are mapped into themselves under inversion with respect to the unit circle. Then the appropriate potential function, after introducing the unit circle is given by

$$g\,(z)=f\,(z)+\bar{f}\left(\frac{1}{z}\right)$$

where bar denotes conjugation.

It can be easily seen that the circle (2) maps into itself on inversion with respect to the unit circle (1).

Also the complex potential (4) has a singularity at $z=b$. Since $b>1$, the distance of this singularity from the origin is greater than 1. Hence applying Levin's Extension, the complex potential due to the circles (1) and (2) is given by

$$w=U\left[(z-b)\,e^{-i\alpha}+\frac{(b^2-1)\,e^{i\alpha}}{z-b}\right]+U\left[\left(\frac{1}{z}-b\right)e^{i\alpha}+\frac{(b^2-1)\,e^{-i\alpha}}{\frac{1}{z}-b}\right] \qquad \ldots(5)$$

3. **Verification** : To show that a particular case of the potential function (5) agrees with a particular case of the potential function obtained by Milne Thomson [1].

Taking $b=\sqrt{2}$ and $\alpha=90^\circ$, the equations of the bounding circles (1) and (2) become

$$\left.\begin{aligned} x^2+y^2&=1 \\ \text{and}\qquad (x-\sqrt{2})^2+y^2&=1 \end{aligned}\right\} \qquad \ldots(6A)$$

and the potential (5) becomes

$$w=-\frac{\sqrt{2}Ui(1-z^2)(1-2\sqrt{2}z+z^2)}{z(z-\sqrt{2})(1-\sqrt{2}z)} \qquad \ldots(6B)$$

where the undisturbed stream is flowing perpendicular to the line of centres.

Now from Milne Thomson [1]

$$w=\frac{2Uci}{n}\cot\frac{\zeta}{n} \text{ where } z=ic\cot\tfrac{1}{2}\zeta$$

is the potential function for flow past a cylinder whose cross section is bounded by

$$\left.\begin{aligned} x^2+y^2+2cy\cot\frac{n\pi}{2}-c^2&=0 \\ \text{and}\qquad x^2+y^2-2cy\cot\frac{n\pi}{2}-c^2&=0 \end{aligned}\right\}$$

and the undisturbed stream flows perpendicular to the line of centres. Putting $c=\frac{1}{\sqrt{2}}$ and $n=\frac{1}{2}$, the equations of the circles become

$$\left.\begin{aligned} x^2+\left(y+\frac{1}{\sqrt{2}}\right)^2&=1 \\ \text{and}\qquad x^2+\left(y-\frac{1}{\sqrt{2}}\right)^2&=1 \end{aligned}\right\} \qquad \ldots(7A)$$

and the corresponding potential function is

$$w=\frac{U(1+12z^2+4z^4)}{2z(1+2z^2)} \qquad \ldots(7B)$$

In order to have the same axes of reference as for equations (6A) and (6B), we put

$$z=\left(z'-\frac{1}{\sqrt{2}}\right)i,$$

$$\text{and}\qquad U=-U'.$$

With these substitutions, after dropping dashes, the equation (7B) becomes

$$w=-\frac{\sqrt{2}Ui(1-z^2)(1-2\sqrt{2}z+z^2)}{z(z-\sqrt{2})(1-\sqrt{2}z)} \qquad \ldots(8)$$

and the eqns. (7A) become identical with eqns. (6A)

The result (8) is in complete agreement with result (6B).

4. **Position of stability.** To investigate this we shall calculate the couple due to the pressure thursts on the cylinder.

By the theorem of Blasius, moment of the couple

$$=\text{Real part of } -\tfrac{1}{2}\rho \int_C \left(\frac{dw}{dz}\right)^2 z\,dz,$$

where ρ is the density of the liquid and C is the contour of the cylinder.

$$\text{From (5), } \frac{dw}{dz} = U\left[e^{-i\alpha} - \frac{1}{z^2}\, e^{i\alpha} - \frac{(b^2-1)e^{i\alpha}}{(z-b)^2} \quad \frac{(b^2-1)e^{-i\alpha}}{(1-bz)^2} \right]$$

so that moment of the couple

$$=\text{Real part of } -\tfrac{1}{2}\, \rho \int_C U^2 \left[e^{-i\alpha} - \frac{1}{z^2}\, e^{i\alpha} - \frac{(b^2-1)e^{i\alpha}}{(z-b)^2} + \frac{(b^2-1)e^{-i\alpha}}{(1-bz)^2} \right]^2 z\,dz$$

$$= -2\rho U^2 \pi \frac{(b^2-1)}{b^2} \sin 2\alpha \qquad \ldots(9)$$

This couple vanishes when $\alpha=0$, or $\frac{\pi}{2}$.

$\alpha=0$ gives a position of instability as the slightest deviation from this orientation calls a disturbing couple into play.

But $\alpha=\frac{\pi}{2}$ gives a stable position as the slightest deviation calls a restoring couple into play.

5. **Stagnation points**, when the undisturbed stream is flowing along the line of centres.

It is easy to see that stagnation points occur at these points of the boundary (1) where $\theta=0$, (2) where $\theta=\pi$, and (3) where the circles intersect. Here θ is the vectorial angle.

6. **Boundary Layer**. In a fluid of small viscosity there is a boundary layer. Following the method of Blasius [4], we shall calculate the velocity in the boundary layer and also the skin friction coefficient. But as the method involves laborious numerical calculation, we choose a simple case.

In eq. (5) putting $b=2$ and $\alpha=\pi$, we get

$$w = -U\left[(z-2) + \frac{3}{z-2} + \frac{1-2z}{z} + \frac{3z}{1-2z} \right], \qquad \ldots(10)$$

when the undisturbed stream is directed towards x positive.

To change the direction of the x-axis so that its positive direction would be from the centre of the bigger circle to the centre of the unit circle, we put $z=-z'$ in eq. (10). After dropping dashes, we get

$$w = U\left[(z+2) + \frac{3}{z+2} + \frac{1+2z}{z} + \frac{3z}{1+2z} \right]$$

$$=U\left[(re^{i\theta}+2)+\frac{3}{re^{i\theta}+2}+\frac{1+2re^{i\theta}}{re^{i\theta}}+\frac{3re^{i\theta}}{1+2re^{i\theta}}\right] \quad ...(11)$$

This is the complex potential for the cylinder whose section is shown below. Here θ is the angular distance of a point on its surface measured from the front stagnation point C.

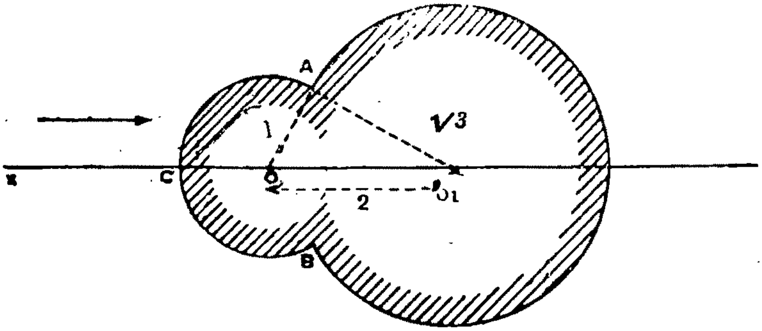

Fig 2.

Now we shall calculate tangential velocity on the unit circle. In the present case this is $-\dfrac{\partial\phi}{r\partial\theta}$ where we have to put $r=1$ after differentiation. But as r and θ are independent, it will not make any difference even if we make $r=1$ before differentiation

Since $\quad w=\phi+i\psi$,

from (11), $\quad (\phi)_{r=1}=U\left[\dfrac{11}{2}+2\cos\theta+\dfrac{9}{2(5+4\cos\theta)}\right]$

Hence $\quad \left(-\dfrac{\partial\phi}{r\partial\theta}\right)_{r=1}=2U\sin\theta\left[1-\dfrac{9}{(5+4\cos\theta)^2}\right] \quad ...(12)$

Denoting this tangential velocity by Q and expanding it in powers of θ, we get

$$Q=2U\left[\frac{8}{9}\theta-\frac{16}{81}\theta^3+\frac{5}{1215}\theta^5-\dots\right], \quad ...(13)$$

the expansion being valid for the values of θ required.

Taking Q as the velocity parallel to the surface at the outside limit of the boundary layer round the unit circle, we have prepared the following table after the manner of Bairstow [5].

In this table $q=$ tangential velocity in the boundary layer;

$\eta=\frac{4}{3}\,n\sqrt{\frac{U}{\nu}}$, where n is the normal distance from the surface;

and $$F=\frac{\text{Skin friction pressure}}{\frac{1}{2}\rho U^2}.$$

	$\frac{q}{U}$				
η	$\theta=0^\circ$	10°	20°	30°	40°
0	0	0	0	0	0
·2	0	·07	·13	·18	·22
·4	0	·13	·24	·34	·40
·6	0	·17	·33	·47	·56
·8	0	·21	·41	·57	·69
1·0	0	·24	·46	·66	·80
1·6	0	·29	·56	·80	·99
2·0	0	·30	·59	·84	1·10
3·0	0	·31	·60	·87	1·10
4·0	0	·31	·60	·87	1·11
F	0	$1.00\sqrt{\frac{\nu}{U}}$	$1{\cdot}91\sqrt{\frac{\nu}{U}}$	$2{\cdot}63\sqrt{\frac{\nu}{U}}$	$3{\cdot}08\sqrt{\frac{\nu}{U}}$

This method is unsuitable for determining the point of separation. We are compelled to take only a first few terms of the Blasius series as the functions appearing only in the first few coefficients of the series have been tabulated.

7. **Point of Separation.** We shall now follow Meksyn [2] to calculate the point of separation. To do so it is desirable to state his result in his notation.

Suppose $W=\alpha+i\beta$,

where α and β are the velocity potential and stream function respectively corresponding to a particular boundary, the speed at infinity being unity in the direction of x positive. Meksyn takes the sign of velocity potential and stream function opposite to what we have taken in the preceding analysis.

Also let $\gamma = l + \alpha$, where l is chosen such that γ vanishes at the front stagnation point.

Let $z = x + iy$, where x and y are cartesian coordinates; also let

$$\left(\frac{dw}{dz}\right)^2 = h^2.$$

Taking U_0 to be the velocity of the undisturbed stream at infinity in the direction of x positive;

$$\left.\begin{aligned} &\text{put } \sigma = \tfrac{1}{2}\left(\frac{2U_0}{\nu r}\right)^{\frac{1}{2}} \beta, \\ &\text{and } \quad \psi = (2\,\nu U_0 \gamma)^{\frac{1}{2}} f\,(\sigma, \gamma) \end{aligned}\right\}$$

where ψ is the viscous stream function in the boundary layer.

With this notation the simplified eq. of two dimensional boundary layer for calculating the point of separation approximately, as obtained by Meksyn [6] is

$$f''' + ff'' = \lambda(1 - f'^2), \qquad \ldots(14)$$

where
$$\lambda = -\gamma_0 \left(\frac{\partial \log h^2}{\partial \alpha}\right)_0. \qquad \ldots(14\text{ A})$$

The dashes denote differentiation with respect to σ and the suffix zero in this expression as well as other expressions of this section denotes the value on the boundary $\beta = 0$. $f\,(\sigma, \gamma)$ has to satisfy the following boundary conditions:—

$$\left.\begin{aligned} & f = \frac{\partial f}{\partial \sigma} = 0 && \text{at } \sigma = 0 \\ \text{and} \quad & \frac{\partial f}{\partial \sigma} = 1 && \text{at } \sigma = \infty \end{aligned}\right\}$$

Now we shall apply eq. (14) to the case of the cylinder whose boundary layer we have discussed above. We shall consider the point of separation on the arc of the unit circle, which will henceforth be denoted by the term 'boundary'.

Adopting Meksyn's notation, from eq. (10) we have

$$W = \alpha + i\beta = \left[\,(z-2) + \frac{3}{z-2} + \frac{1-2z}{z} + \frac{3z}{1-2z}\right] \qquad \ldots(15)$$

(Refer to fig. 2, with the direction of x-axis reversed.)

From this we have to calculate $-\gamma_0\left(\frac{\partial \log h^2}{\partial \alpha}\right)_0$ in terms of θ. From eq. (15) it is clear that h^2 will be a cumbersome expression. And thence to calculate $\frac{\partial \log h^2}{\partial \alpha}$ would be a complicated affair, so we proceed as follows ;—

Since α and β are independent, we can put $\beta=0$ or $r=1$ before differentiation *w.r* to α.

From (15) $\dfrac{dW}{dz}=\left[1-\dfrac{3}{(z-2)^2}-\dfrac{1}{z^2}+\dfrac{3}{(1-2z)^2}\right]$

$$\therefore\ (h^2)_0=\left|\left(\frac{dW}{dz}\right)_0\right|^2=\frac{256\sin^2\theta\,(2\cos\theta-1)^2\,(\cos\theta-2)^2}{(5-4\cos\theta)^4}, \qquad \ldots(16)$$

putting $z=e^{i\theta}$.

$$\text{Now}\left(\frac{\partial\log h^2}{\partial\alpha}\right)_0=\frac{d}{d\theta}(\log h^2)_0.\left(\frac{\partial\theta}{\partial\alpha}\right)_0 \qquad \ldots(17)$$

putting $z=e^{i\theta}$ in (15), we have

on the boundary, $(\alpha+i\beta)=-\dfrac{11}{2}+2\cos\theta-\dfrac{9}{2\,(5-4\cos\theta)}$,

$$\text{whence, on the boundary, }\alpha=-\frac{11}{2}+2\cos\theta-\frac{9}{2\,(5-4\cos\theta)}. \qquad \ldots(18)$$

$$\text{Hence}\quad\left(\frac{\partial\theta}{\partial\alpha}\right)_0=\frac{d\theta}{d\alpha}\text{ on the boundary}$$

$$=-\frac{(5-4\cos\theta)^2}{16\sin\theta\,(2\cos^2\theta-5\cos\theta+2)}, \qquad \ldots(19)$$

from eq. (18).

From (16), (17) and (19) we have

$$\left(\frac{\partial\log h^2}{\partial\alpha}\right)_0=\frac{(5-4\cos\theta)\,(8\cos^4\theta-30\cos^3\theta+42\cos^2\theta-10\cos\theta-9)}{8\sin^2\theta\,(2\cos^2\theta-5\cos\theta-2)^2} \qquad \ldots(20)$$

Also $\gamma=l+\alpha$ as stated above,

and γ is to vanish at the forward stagnation point C i.e. $\theta=\pi$ whence $l=8$.

$$\text{So}\quad\gamma_0=l+(\alpha)\text{ on the boundary}$$

$$=\frac{8\sin^2\theta}{5-4\cos\theta}. \qquad \ldots(21)$$

From (14 A), (20) and (21),

$$\lambda=\frac{-(8\cos^4\theta-30\cos^3\theta+42\cos^2\theta-10\cos\theta-9)}{(2\cos^2\theta-5\cos\theta+2)^2} \qquad \ldots(22)$$

At the point of separation, the surface friction vanishes i.e. $f''(0)=0$.

Hartree [6] has solved the eq. (14) numerically for various values of λ. The following table is based on his work.

λ	0	·1	·14	·16	·18	·19	·1988
f″(0)	·4696	·3191	·2395	·1905	·1285	·086	·0000

This shows that the point of separation occurs when $\lambda = \cdot 1988$.

Hence from (22)

$$\frac{-(8\cos^4\theta - 30\cos^3\theta + 42\cos^2\theta - 10\cos\theta - 9)}{(2\cos\theta^2 - 5\cos\theta + 2)^2} = \cdot 1988$$

This gives $\theta = 105^\circ\ 52'$ approximately.

Hence the angular distance of the point of separation from the forward stagnation point $= 74^\circ\ 8'$ nearly.

In conclusion, I want to thank Prof. M. Ray, D. Sc., for guidance.

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ROLE OF SOME NEW TRANQUILLIZERS IN PSYCHIATRY*

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Introduction

Through its long and chequered history, psychiatry has witnessed many novel and sometimes quite disreputable therapeutic endeavours. Some of these attempts have flowered briefly in the warmth of human hopes only to wither away under the harsh glare of public scrutiny. Pharmacological treatment of mental disorder is not of course new like hellebore, opium, camphor, bromides, paraldehyde and the barbiturates cover a large part of the history of the psychiatric therapy. Since 1951 we have seen the beginning of remarkable new developments in the pharmacological approach to psychiatry. Perhaps never before in the field of emotional conflict have so many medicines been consumed by so many patients with so many diverse results as in psychiatric hospitals during the last few years that have seen the birth of ataractic Era or Era of tranquillizers and these new pharmacological drugs with the genetic title of tranquillizers have been introduced of which the best known are chlorprom azine and reserpine which have been studied in detail clinically by us.

The word tranquillizer means to calm or relieve tension. These drugs are called tranquillizers because they have the characteristic effect of producing sedation without sleep.

The tranquillizers that are commonly used in various mental hospitals here and abroad, belong to the following groups.

1. Reserpine.
2. Chlorpromazine Hydrochloride.
3. Mapazine.
4. Azacyclonal.
5. Meprobamate.
6. Benactyzine.
7. Hydoxyzine.
8. Promazine.
9. Acetyl promazine.
10. Covatin.

Out of these drugs from four groups were tried namely Reserpine Chlorpromazine hydrochloride, Benactyzine and Meprobamate. Reserpine and chlorpromazine have been extensively used and advocated for the treatment of every condition from anxiety to zoophobia. These drugs are in wide spread use despite the fact that adequate criteria for treatment are lacking that authoritative reports are scarce and that dangers are not fully explored. The use of these drugs has become extensive because they are generally safe, almost universally effective in some degrees, easy to administer and do not ordinarily impair consciousness.

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*This is an abstract of the thesis submitted for the M. D. Degree of the Agra University in the year 1958.

We have all heard so many penegyrics on these drugs that an attempt at their collective apprisal might help to clarify the present position. Several workers worked on these drugs and their observations are of clinical interest. Delay and Deniker 3, Antonstephen 1, Lehmannand Hanrahan 12, Winkelman 15, Elkes and Elkes 4, Kinross wright 10, Vaughan etal 13, Goldman 6, Hognall 7, Kline 9, have used chlorpromazine on various types of patients. Franco Rinaldl and Himwich 13, N.S. Kline and A.M. Stanely 11, Hollister etal 8, Flach 5 and M. Bleuler and Stoll 2, have worked on reserpine and their reports are encouraging.

We under took the study with a view to investigate the psycho-pathologic effects of these two extensively used drugs (Chlorpromazine and reserpine) in hospitalised patients under the existing conditions in the Mental Hospital, Agra and to clarify specific indications, dosages and toxicity etc. We could use meprobamate and Banactyzine only in a few Psychoneurotic patients as most of them are not hospitalised.

MATERIAL AND METHOD

Our survey included the male and female acute and chronic Psychotic patients. These were all indoor patients, admitted in the Mental Hospital, Agra. Most of the acute cases were admitted during the latter part of the year 1956 and 1957 and the duration of illness was mostly within a year. The chronic cases were of long duration ranging from 3 to 16 years. The duration of stay of acute cases in Hospital was never less than a month and in most cases 3 months or longer. Some of the patients had not shown improvement with electric convulsive therapy at all, some had after showing improvement again deteriorated. One patient had not shown improvement with insulin coma therapy, and one patient remained excited and violent even after insulin Coma therapy and leucotomy.

Majority of the patients were Schizophrenics, then were the patients of Affective Psychosis, mostly mania. The remainder included cases of Psychoneurosis (mostly not hospitalised) Involutional melancholia, Disturbed mental deficiency, Senile psychosis, and Organic psychosis. There were 5 such cases who were treated first with largactil and then with serpasil and one wtih Serpasil first and later on with largactil.

The following drugs were used in our series :—

1. Largactil (Chlorpromazine)
2. Serpasil (Reserpine)
3. Miltown (Meprobamate)
4. Suavitil (Benactyzine)

No. of cases—Males	80
Females	20
Total	100

1 to 15 years	2
16 to 25 years	33
26 to 35 years	38
36 to 45 years	14
46 to 55 years	9
56 to 65 years	4
Total	100

Distribution of cases treated with various drugs.

(A) Chlorpromazine (Largactil)	Schizophrenia	43
	Mania	25
	Involutional Melancholia	2
	Agitated depression	1
	Disturbed mental deficiency	2
	Psychoneurosis	2
(B) Reserpine (Serpasil)	Schizophrenia	4
	Mania	18
	Organic Psychoses	1
	Involutional Malancholia	1
	Senile Psychosis	1
(C) Meprobamate (Mil town)	Psychoneurosis	2
	Agitated depression	1
(D) Benactyzine (Suavitil)	Psychoneurosis	2
	Involutional Melancholia	1

Distribtution of cases sex-wise under each drug

Chlorpromazine	Males	61
	Females	14

Reserpine	Males	20
	Females	5
Meprobamate	Males	2
	Females	1
Benactyzine	Males	3

Distribution of cases in relation to social status

Upper class	4
Upper Middle class	15
Lower Middle class	65
Lower class	16

Note:—*Division is arbitrary*

Duration of treatment

1. Maximum duration	105 days
2. Minimum duration	15 days

Distribution of cases (drugwise and Sex-wise) in relation to condition of patients

		Male	Female
Chlorpromazine	Acute cases	52	12
	Chronic cases	9	2
Reserpine	Acute cases	13	4
	Chronic cases		1
Meprobamate	Acute cases	2	1
Benactyzine	Acute cases	3	-

Distribution of cases in relation to personality

Schizoid	45
Syntonic	40
Paranoid	2
Depressive	1
Mixed	7
Psychopathic	2
Unknown	3

Distribution of cases under each drug in relation to duration of illness

Chlorpromazine	upto 6 months	53 cases
	6 months to 1 year	1 case
	1 year to 5 year	13 cases
	5 year to 16 years	3 cases

---

*Other personalities are included in mixed.

Reserpine	Upto 6 months	17 cases
	1 year to 5 year	6 cases
	5 years to 16 years	1 case
Meprobamate	Upto 6 months	3 cases
Benactyzine	Upto 6 months	1 case
	6 months to 1 year	2 cases
		100

Distribution of cases in relation to attack

Majority were having first attack
Rest had a few attacks before

Number of cases treated with others therapies

Electric convulsive therapy	51
Insulin coma therapy	2
Leucotomy	1

METHOD

After a diagnostic and prognostic evaluation and complete physical examination and also laboratory examination, the patients were put on tranquillizer therapy. The drug was administered orally mostly—The doses were increased gradually usually, except in acute cases, where it was increased quickly.

The dose ranged from 200 mg. to 600 mg. in case of chlorpromazine and 4 mg. to 12 mg. daily in case of reserpine. The maximum dose was maintained 7-14 days in both cases and then gradually reduced to maintenance dose. Parentral method was utilised only in excited and non-cooperative cases. When side effects appeared the drug was either reduced or withdrawn completely. In case of meprobamate the dose ranged from 400 mg. to 1600 mg. daily and with benactyzine 1 mg. to 3mg. daily was given. In assessing the improvement of the mental state of the patients, their symptoms, behaviour, and reactions, the general opinion of the attending staff and patients, relations were taken into consideration. No Psychological tests were done. The evaluation was done at a clinical level.

OBSERVATION

100 cases were studied in this series.

1. *Sex distribution*

Male	80%
Female	20%

2. *Age group*

16 years to 25 years	33
26 years to 35 years	38
36 years to 45 years	15

3. *Drugwise distribution of cases*

Largactil	74+1
Serpasil	20+5
Mil town	3
Suavitil	3

4. *Disease wise distribution of cases under various drugs*

Disease	No.	Largectil	Serpasil	Miltown	Suavitil.
Schizophrenia	46	43	3+1	-	-
Mania	38	24+1	3+5	-	-
Involutional Melancholia	4	2	1	-	1
Agitated depression	2	1	-	1	-
Psychneurosis	6	2	-	2	2
Disturbed mental Deficiency	2	2	-	-	-
Senilepsychosis	1	-	1	-	-
Organic Psychosis	1	-	1	-	-

Results with therapeutic trial of largectil

	CR	M.I.	S.I.	N.I.
A *Schizophrenia*				
Paranoid	6	4	6	3
Catatonic	2	2	1	1
Hebephrenic	-	-	3	1
Simple	-	2	1	-
Chronic	1	2	6	2

In paranoid out of 19 patients 16 patients improved

	CR	M.I.	S.I.	N.I.
B *Mania*				
Acute	3	-	1	3
Hypomania	5	5	4	4
C *Other diseases*				
Involutional Malancholia	1	-	1	-
Agitated Depression	-	1	-	-
Psychoneurosis	-	1	-	1
Schizophrenia with mental deficiency	1	-	1	-

RESULT WITH SERPASIL TRIAL

1. *Schizophrenia*				
Paranoid	-	-	-	1
Simple	-	1	-	-
Chronic	-	1	-	1

2. *Mania*				
Acute	4	1	-	1
Hypomania	4	3	4	1
3. *Other diseases*				
Involutional Melancholia	-	-	1	-
Senile	-	-	1	-
Taxic Psychosis	1	-	-	-

RESULTS WITH SUAVITIL TRIAL

	C.R.	M.I.	S.I.	N.I.
Psychoneurosis	-	-	1	-
Agitated depression	-	2	-	-

Recovery Rate versus Nonfavourable personalities and constitution

(MANIA & SCHIZOPHRENIA)

		C.R.	M.I.	S.I
1. *Mania*				
Personality	Constitution			
Schizoid or mixed	Asthenic or A typical			
3	16	6	5	3
2. *Schizophrenia*				
Syntonic or mixed	Pyknic or Atypical			
2	18	2	7	8

The nonfavourable personality and consitution appears to help recovery rate.

Main Drugs versus recovery rate

	No. of cases	Improved
Largactil	75	60
Serpasil	25	21

Recovry rates versus Social Status (lower class)

Schizophrenia	Total No.	Not improved or slightly improved
Paranoid	2	2
Simple	1	1
Hebephrenic	3	2
Chronic	1	1

It appears social status does play some part.

Age Versus recovery rate

Age	C.R.	M.I.	S.I.	N.I.
16 years—25 years	11	8	10	4
26 years—35 years	12	14	7	5
36 years—45 years	2	2	7	3
other groups	2	3	6	4

Drug wise average dose

	No. of cases	Total maximum dose	Average dose
Largactil	75	18575 m.g.	250 m.g.
Serpasil	25	(approx) 140	5.5 m.g.

Side effects with main drugs

	Largactil	Serpasil
Drowsiness	2	3
Parkinsonism	1	2
Dizziness	2	1
Hypotension	3	5
Jaundice	2	-
Diarrhoea	2	-
Incontinence of urine	-	1
Stuffiness	3	-
Tacchycardia	10	-
Palpitation	2	-
Pyrexia	2	-
Brady cardia	-	8
Tremulousness	1	2
Giddiness	2	1

DISCUSSION

The tranquillizers have been a major force in firmly launching us into the era of Psycho-pharmacology. We are still suffering, however, from all the uncertainties and hesitation of a pioneer venture. It will still take some years before the true role of tranquillizers, their value, and the dangers and the disadvantages of the tranquillizing drugs can be completely assessed. Objective and skilled assessment of their long term effects in a large series of patients under adequately controlled conditions are necessary before their exact indication in Medical practice can be established. The large number of similar drugs and the innumerable disseases in which they are said to be effective are indi-

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1. C. R.—Complete recovery.
2. M. I.—Marked improvement.
3. S. I.—Slight improvement.
4. N. I.—Not improved.

cations of our present inadequate knowledge. However, we feel a new era of tranquillizers has begun and that the outlook of patients suffering from Mental agitation is better than it ever has been. Already with these drugs great relief is provided to some hopeless schizophrenic and manic patients, however, the very high cost has been a drawback. English advocated moderate doses while American have gone to extremely high daily doses. The improvement rate for all catagories of patients was with largactil 80% and with serpasil 84%. The inverse relationship of duration of illness and the therapeutic results hold true for schizophrenia and mania. The patients ill longest showed the poorest response and recovery. The toxic effects in our series were all reversible. The encouraging results obtained in this series confirm the usefullness of Psychotic-Schzophrenic as well as Affective excitements-specially in those where E.C.T. failed. In cases where onset was sudden, of short duration without previous mental illness in them or infamily, maximum improvement was noticed. Younger patients showed better results. Within a week or ten days behaviour of excited patients improved after initiating treatment.

Hallucinations disappeared earlier than delusions. In delusions, suspicions and grandiosity took longer time than other ones. Early paranoid cases showed excellent results. Chronic Schizophrenics who had shown tension all along showed gradual but significant improvement in their behaviour and calmed down progressively.

In manics results were quite encouraging but not to the extent as in paranoid. Chlorpromazine does not protect from relapse, if discontinued early after discharge. Since its exact effectiveness cannot be accurately predictd chlorpromazine must be initiated for 4-8 weeks trial. This therapy is as sensitive and skilled procedure as insulin is in diabtics or anticonvulsants in epileptics. Resistance to Psychotherapy makes effective use of chlorpromazine all the more important.

Reserpine—Its introduction is a useful advance in Psychiatry. This is the only available drug that significantly reduces motor excitement without at the same time, producing confusion, lithargy and deep sleep. On the basis of our trial reserpine appears to have definite though limited place in the treatment of psychiatric disorders.

Other drugs miltown and suavitil were not given sufficient trial.

It was observed that if a patient was refractory to one tranquillizer another tranquillizer did not improve the condition. We have clearly observed that basic similarities and differences exist in clinical effects of chlorpromazine and reserpine. Curiously enough, however, two new important drugs discovered and made known under completely different circumstances were introduced into psychiatry within the same year. Both the drugs if given adequately soothe and relax patients remarkably to an extent formerly unknown.

CONCLUSION

1. The usefulness of drugs in the management of Psychiatric *i.e.*, Schizophrenia and Affective disorders specially where electric convulsive therapy had failed has been confirmed.
2. Maximum improvement was seen in early cases and younger patients.
3. Lower class patients showed poorer response than upper ones.
4. Acute Schizophrenics specially paranoid type showed excellent results.
5. Behaviour improved earlier than other faculties.
6. Hallucinations responded earlier than delusions in which persecution and others disappeared earlier than grandiosity.
7. One unimproved leucotomy case showed marked improvement.
8. Chlorpromazine had diffinitely reduced the utility of electric convulsive and Insulinicoma therapies.
9. Trial with reserpine showed quite satisfactory results in mania.
10. Meprobamate and Benactyzine have some tranquility in psychoneurotic patients with tension.

SUMMARY

100 cases were studied in this series.

1. Chlorpromazine has been proved to be the drug of choice in paranoid schizophrenia showing tension, to a lesser extent in mania and chronic schizophrenia.
2. Reserpine has been proved drug of choice in cases of mania.
3. Meprobamate and Benactyzine were beneficial in psychoneurotic patients with tension.

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CONTENTS

PAGE

1. Rotatory Dispersion of Ammonium Salt of D-Camphor-β-Sulphonic Acid. By O. N. Perti and B. C. Pant 1
2. Condensation of Some Aliphatic, Aromatic and Heterocyclic Aldehydes with Chloracetamide. By Abraham Thomas and T. George 11
3. Condensation of Malon-o-, M-And P-Chloranilic Acids with Aldehydes—Part V—with Vanillin and Piperonal. By M. V. George and P. I. Ittyerah 15
4. Contribution of Valence Bonds of a Gaseous Molecule to γ-the Ratio of its two Specific Heats. By Wazir Chand Vasudeva and Ram Swarup Singh 21
5. Some New Self Reciprocal Functions. By Gopal Krishna ... 27
6. Some Aspects of the Bionomics of Earias Spp. at Kanpur. By C. P. Pant 31
7. Distribution of Vitamin C in the Oogenesis of *Mylabris Pustulata* (Thunb)-(Coleoptera). By Udai Vir 41
8. Morphology of the Head Capsule of *Aspongopus Fanus* Fabr (Pentatomidae : Heteroptera). By L. G. Banerji 47
9. Entomological Survey of Himalaya. Part XXX-on some Chrysomelidae (Coleoptera) From the North-West (Punjab) Himalaya. By S. P. Shukla 65
10. Faunistics, Taxonomy, Field Ecology, Adaptations and Zoogeography of the High Altitude Insects from the North-West Himalaya. By Santokh Singh 89
11. Secondary Growth in *Urtica Dioica* L. By S. C. Gupta ... 93
12. Organogeny and Floral Anatomy of *Nannorrhops Ritchieana* H. Wendl. By Shrish C. Gupta 103
13. Studies in the Umbellales—I. An Abstract. By S. P. Mittal 113
14. Study of Carbanion Formation in α-Halogenated Acetophenones Through Synthesis and Reactions of α-Bromo-α-Isonitroso Acetophenones. By O. N. Perti and G. C. Singhal ... 121
15. Damping off of Cucurbitaceous Vegetables and its Control. By B. B. Nagaich and Babu Singh 125
16. Studies on a Luxuriant Form of Teosinte and its Hybrids with Maize. By Bahadur Singh and R. L. Paliwal 137
17. Streaming past a Cylinder whose Section is Bounded by two Circles Intersecting Orthogonally Irrotational Motion and Boundary Layer. By Jyoti Prasad Agarwal 147
18. Role of some New Tranquillizers in Psychiatry. By K. P. Nigam 157

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STUDY OF CARBANION FORMATION IN KETONES THROUGH SYNTHESIS AND REACTION OF ISONITROSO AND NITROSO KETONES

O. N. Perti, M. Sc., D. Phil., *Professor of Chemistry*, and
G. C. Singhal, M. Sc., *Research scholar, Th. D. S. B. Govt. College, Nainital.*

Summary

The carbanion formation in ketones through synthesis and reaction of nitroso and isonitroso ketones have been studied. Representative cases of open chain, aromatic and cyclic ketones were taken. Study of nitrosation reveals that in case of open chain ketones the carbanion formation takes place at methylene in methyl ethyl ketone and at methyl group in case of acetone, methyl-*n*-propyl ketone, methyl-*n*-amyl ketone, methyl-*iso*-propyl ketone. In case of aromatic ketones the carbanion formation takes place at the methyl group while in case of cyclic ketones it takes place at methylene group.

Introduction

In an earlier communication (1) one of us studied the mechanism of formylation of esters and brought out clearly the salient features of ethyl formate molecule. The carbanion formation in halogen esters through synthesis and reactions of formyl—chloro ethyl acetate, formyl—bromo ethyl acetate and β-chloro-α-formyl ethyl propionate was discussed. In the present paper the study of carbanion formation has been extended to the open chain ketones, aromatic ketones and cyclic ketones. The study relates to the synthesis of some known (2) and unknown isonitroso ketones and preparation of their copper chelates. The reaction studied analytically is nitrosation which may be taken to be a particular case of acylation.

EXPERIMENTAL

The synthesis and reactions of isonitroso (acetone, methyl ethyl ketone, diethyl ketone, methyl-*n*-propyl ketone and methyl-*n*-amyl ketone) (2); isonitroso camphor (3) and isonitroso acetophenone (4) are well known. But the authors synthesised the above mentioned isonitroso ketones along with some new insonitroso ketones by the following two modified methods which are not previously described.

METHOD I

A mixture of ketones and amyl nitrite was taken in equimolecular proportions. This mixture was gradually added, in small amounts at a time to a suspension of sodium ethylate in dry ether. The contents were kept over night at 0°C to complete the reaction. The sodium salt was filtered at the pump, washed with dry ether and then suspended in ice cold water and decomposed with dilute sulphuric acid. The product was extracted with ether and dried over anhydrous calcium chloride. On removal of ether by evaporation, a gummy product was obtained which was solidified with petroleum ether. It was crystallised from carbon tetrachloride or benzene.

METHOD II

In this a mixture of ketones and dry ether saturated with hydrogen chloride gas was taken in a round bottomed flask. Pure isopropyl or amyl nitrite (molar proportion) was added drop by drop and the mixture mechanically stirred till it became light yellow. It was left over night. The organic layer was washed with water and then dried over anhydrous calcium chloride. On evaporation a solid was obtained which was crystallised from benzene or carbon tetrachloride.

The general properties of new isonitroso ketones:

The compounds were all white solids except isonitroso cyclohexanone which was of dark brown colour. They all reduced Fehling's solution and gave violet colour with ferric chloride. They were soluble in ether and alcohol, sparingly soluble in water, carbon tetrachloride and benzene.

Copper Chelates:

Isonitroso ketones when treated with aqueous solution of copper acetate usually formed copper chelate complexes.

Their names, melting points and melting points of copper complexes are recorded in Table 1.

Table 1

Characteristics of isonitroso compounds

No.	Name	Melting Point	Copper acetate complex M.P.
1.	Isonitroso acetone. (2)	66°C	190°d.
2.	Isonitroso methyl ethyl ketone (2)	73°C	151°d.
3.	Isonitroso diethyl ketone (2)	69°C	145°C
4.	Isonitroso methyl-*n*-propyl ketone (2)	56°C	Unstable (?)
5.	Isonitroso methyl-*n*-amyl ketone (2)	51°C	Unstable (?)
*6.	Isonitroso methyl-*iso*-propyl ketone	91°C	Unstable (?)
7.	Isonitroso camphor (3)	151°C	65°C
*8.	Isonitroso cyclohexanone	72°d.	200°d.
9.	Isonitroso acetophenone (4)	126°C	210°d.
*10.	Isonitroso-*p*-chloro acetophenone	170°C	130°d.
*11.	Isonitroso-*p*-methoxy acetophenone	140°C	150°d.
*12.	Isonitroso methyl-*β*-naphthyl ketone	172°C	220°d.

* New isonitroso ketones.

(i) fusion with caustic soda solution gave corresponding acids.
(ii) Analysis of C, H, and N.

*No. 6. Found : C=52.98%; H=7.32%; N=11.9%
$C_5H_9O_2N$ requires C=52.1% ; H=7.82% ; N=12.17%

*No. 8. Found : C=55.8% ; H=7.1% ; N=11.03% ;
$C_6H_90_2N$ requires C=56.6% ; H=7.08% ; N=11.02%

*No. 10. Found : C=52.5% ; H=3.4% : N=6.9% ; Cl=20% ;
$C_8H_80_2NCl$ requires C=52.3% ; H=3.2% ; N=7.6% ; Cl=19.1%

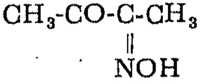
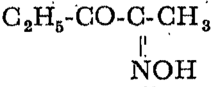
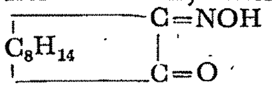
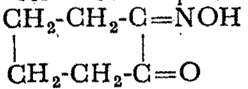
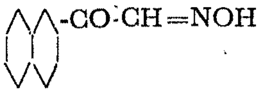
*No. 11. Found : C=59.4% ; H=4.1% ; N=6.93% ;
$C_9H_90_3N$ requires C=60.3% ; H=5.02% ; N=7.8%

*No. 12. Found : C=71.9% ; H=4.4% ; N=7.1%
$C_{12}H_90_2N$ requires C=72.3%; H=4.5%; N=7.03%

All the compounds prepared were subjected to oxidative fission by Kiliani's dichromate mixture and the products obtained by oxidative fission are recorded in Table 2.

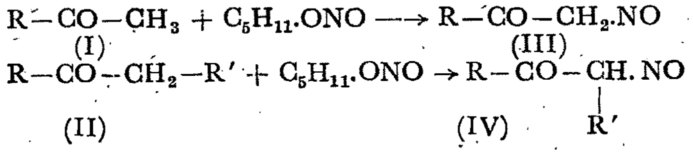
Table 2

Products of oxidative fission

Name and structure of compound	Product of oxidative fission	
	Name and structure	M. P. or B. P. and other characteristics
1. $CH_3\text{-}CO\text{-}CH{=}NOH$ Isonitroso acetone	CH_3COOH Acetic acid	118°C; Eq.Wt. Obs: 58.9. Cal: 60.
2.  $CH_3\text{-}CO\text{-}\underset{\underset{NOH}{\Vert}}{C}\text{-}CH_3$ Isonitroso methyl ethyl ketone.	CH_3COOH Acetic acid	B. P. 117°C Eq.Wt. Obs: 58.2 Cal: 60
3.  $C_2H_5\text{-}CO\text{-}\underset{\underset{NOH}{\Vert}}{C}\text{-}CH_3$ Isonitroso diethyl ketone	$CH_3.CH_2COOH$ Propionic acid	B. P. 138°C Eq.Wt. Obs: 73.3 Cal: 74
4. $C_3H_7\text{-}CO\text{-}CH{=}NOH$ Isonitroso methyl-*n*-propyl ketone	$CH_3\ (CH_2)_2COOH$ *n*-butyric acid	B. P. 160°C Eq.Wt. Obs: 86.9 Cal: 88.9
5. $C_3H_7\text{-}CO\text{-}CH{=}NOH$ Isonitroso methyl isopropyl ketone	$(CH_3)_2CH.COOH$ iso-butyric acid	B. P. 155°C Eq.Wt. Obs: 85.23 Cal: 88.9
6. $C_5H_{11}\text{-}CO\text{-}CH{=}NOH$ Isonitroso-*n*-amyl ketone	$CH_3(CH_2)_4COOH$ *n*-caproic acid	B. P. 202°C Eq.Wt. Obs: 114.3 Cal: 116
7.  Isonitroso camphor	$C_8H_{14}(COOH)_2$ Camphoric acid	M. P. 187°C Eq.Wt. Obs: 199 Cal: 200
8.  Isonitroso cyclohexanone	$(CH_2)_4COOH)_2$ Adipic acid	M. P. 150°C Eq.Wt. Obs: 114.9 Cal: 114
9. $C_6H_5\text{-}CO\text{-}CH{=}NOH$ Isonitroso acetophenone	C_6H_5COOH Benzoic acid	M. P. 121°C Eq.Wt. 121 Cal: 122
10. $Cl\text{-}C_6H_4\text{-}CO\text{-}CH{=}NOH$ Isonitroso-*p*-chloro acetophenone.	$Cl\text{-}C_6H_4COOH$ *p*-chloro benzoic acid.	M. P. 235°C Eq.Wt. Obs: 155.1 Cal: 157
11. $OCH_3\text{-}C_6H_4\text{-}CO\text{-}CH{=}NOH$ Isonitroso-*p*-methoxy acetophenone.	$OCH_3\text{-}C_6H_4COOH$ *p*-methoxy benzoic acid	M. P. 184°C Eq.Wt. Obs: 153.9 Cal: 152.
12.  Isonitroso methyl-β-napthyl ketone.	$C_{10}H_7COOH$. β-Naphthoic acid.	M. P. 181°C Eq.Wt. Obs: 170.1 Cal: 172

DISCUSSION

The location of carbanion formation in unsymmetrical ketones has been observed in the synthesis of hydroxymethylene compounds by several workers (5). Here by the action of amyl nitrite on ketones of the type (I) and (II), the nitroso products (III) and (IV) would be formed.



$$\underset{(I)}{R-CO-CH_3} + C_5H_{11}.ONO \longrightarrow \underset{(III)}{R-CO-CH_2.NO}$$

$$\underset{(II)}{R-CO-CH_2-R'} + C_5H_{11}.ONO \rightarrow \underset{(IV)}{R-CO-\underset{\displaystyle R'}{\underset{|}{C}}H.NO}$$

It may be noted that in these nitroso ketones two triad systems —O=C—C (H) and (H) C—N=O— are superimposed, which would give rise to a pentad system. Theoretically, therefore, the nitroso ketones can exist in the following forms :

$$\underset{(V)}{R-C(OH)=CH-NO} \rightleftharpoons \underset{(III)}{R-CO-CH_2-NO} \rightleftharpoons \underset{(VI)}{R-CO-CH=N-OH}$$

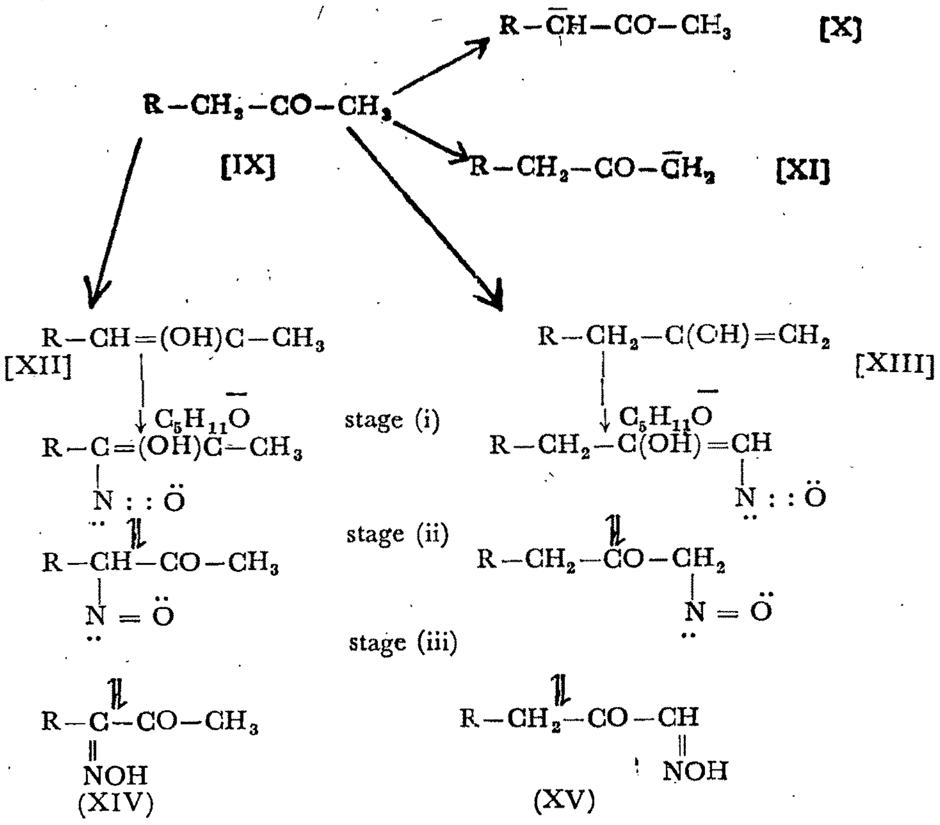
$$\underset{(VII)}{R-C(OH)=CR'-NO} \rightleftharpoons \underset{(IV)}{R-CO-CHR'-NO} \rightleftharpoons \underset{(VIII)}{R-CO-CR'=N-OH}$$

In an equilibrium mixture all the three forms may co-exist but owing to their acid character they are usually written as isonitroso ketones (hydroxy imino ketones). This system is very much like the pentad system of 2—formyl ketones (6) except that the trivalent (=CH—) of 2—formyl ketone is replaced by the trivalent (=N—) in nitroso ketones. Hence they should behave similarly.

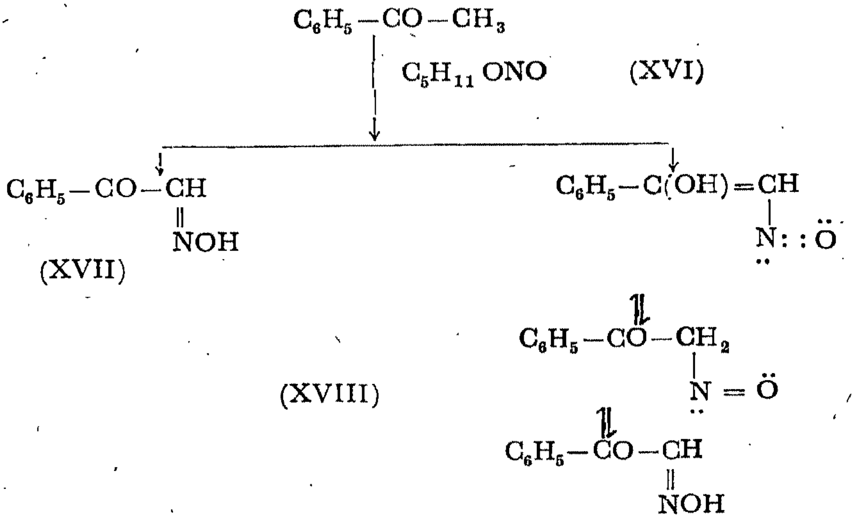
In 1932 Ellworth (7) advanced the view that in such compounds the electrons of the nitrogen atom are more nearly similar to those of the oxygen atom than those of carbon. This implies that in a system where there is competition between oxygen and nitrogen for the four electrons (e.g., in case of the nitroso form) the system would tend to go in the direction in which [N] will not compete with [O] but will compete with [C] (i.e., the isonitroso form).

In the present paper the authors have investigated the carbanion formation through nitrosation. The reaction studied may be represented under three catagories viz. open chain ketones, aromatic ketones and cyclic ketones, each of them should give rise to following types of compounds:

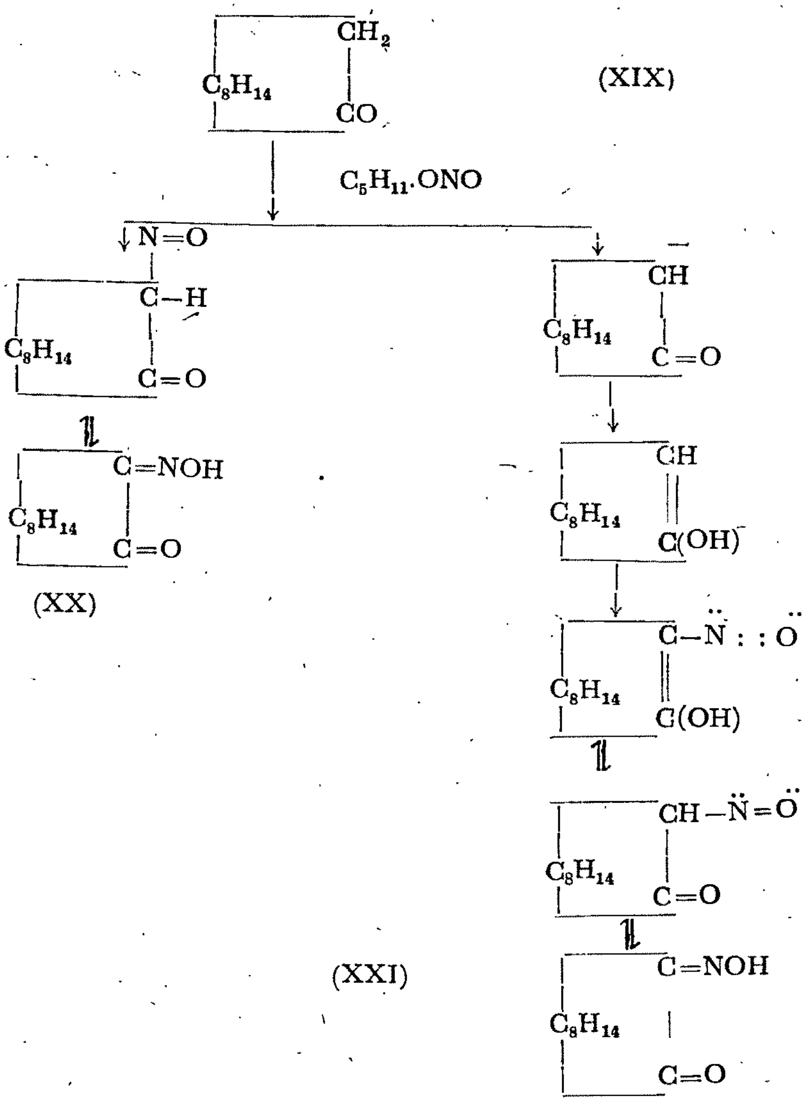
Type I—Open chain ketones



Type II—Aromatic ketones



Type III—Cyclic ketones



Thus in each case by the action of amyl nitrite two isomeric derivatives should be formed. Actually, however, only one form is obtained. The structure of this form can be arrived at by studying the acid isolated after oxidative fission by potassium dichromate. In case of open chain ketones, amyl nitrite molecule is such that it cannot form carbanion needed for the reaction at stage (i). Hence it can only behave as an acceptor at stage (ii) of the reaction. This behaviour results only in nitrosation of ketones. Hence the structure of the hydroxy imino ketones would indicate which carbanion (X, XI) is formed. Thus in case of methyl ethyl ketone and diethyl ketone (IX, $R=CH_3$; $IX=C_2H_5-CO-CH_2.\ CH_3$) it has been shown that nitrosation takes place at methylene group, while in the case of acetone (IX, R=H), methyl *n*—propyl ketone (IX, $R=C_3H_7$) methyl—*iso*, propyl ketone (IX, $R=C_3H_7$), and methyl *n*—amyl ketone (IX, $R=C_4H_9$) it takes place at the methyl group.

In case of aromatic ketones the nitrosation takes place at the methyl group while in the case of cyclic ketones the nitrosation takes place at the methylene group.

CONCLUSION

The carbanion formation in ketones through synthesis and reactions of nitroso and isonitroso ketones have been studied. Representive cases of open chain, aromatic and cyclic ketones were taken. Study of nitrosation reveals that in case of open chain ketones the carbanion formation takes place at methylene in methyl ethyl ketone and diethyl ketone; at methyl group in case of methyl *n*—propyl and methyl *n*—amyl ketone. In case of aromatic ketones the carbanion formation takes place at the methyl group while in the cyclic ketones it takes place at methylene group.

ACKNOWLEDGEMENT

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PAPYROGRAPHIC CHARACTERIZATION OF NON-VOLATILE ORGANIC ACIDS IN SOME MEDICINAL PLANTS OF NAINI TAL

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A large variety of plants are found in Kumoan region in the Himalayas which is very rich in vegetation. Besides economic point of view, some wild plants growing in this region are medicinally very important. Crude extracts of these plants are used in different diseases and ailments by poor villagers who cannot afford to purchase costly medicines. A number of such crude extracts of plants are even today used by them in cases of kidney troubles, blood pressure, different types of haemorrhage, blood poisoning, fevers, eye troubles, cases of general weakness, eczema and skin diseases, dysentry and different body pains.

The non-volatile organic acids present in some wild edible fruits of Naini-Tal have been reported by Gupta and Gupta (1,2 and 3). A number of medicinally important plants are being investigated in this laboratory for the characterization of different organic compounds present in them. In the present article, the non-volatile organic acids present in seven such medicinal plants are being communicated

Experimental

Extracts of plants were prepared by crushing them in a glass mortar and then centrifuged for 10-15 minutes at 4,000 r.p.m. The supernatent liquid was removed and used for identification. In some cases where juice could not be extracted easily, a small amount of distilled water was added before crushing was done. The concentration of the plant extracts was increased by first spotting 0·002—0·004 ml on Whatman filter paper No. 1, drying and then putting the same volume at the same spot at a number of times. Thus the desired concentration was obtained on the filter paper by trial in order to make sure that the spots did not give streaks with further concentration.

For the characterization of organic acids, the circular paper chromatographic technique was employed. A large circular trough 15 cms. deep and 29 cms. in diameter, was used. A circular ring made of glass (diameter 26 cms.) served as a support for the paper. A small petri dish, in which the developing solvent was taken was placed at the centre of the circular trough. Circular sheets (diameter 27 cms.) of Whatman filter paper No. 1 were used. A pencil circle of about 2 cms. was drawn in the centre of the paper, and the circle was divided into 8 equal parts, by drawing lines diagrammatically. The plant extracts and known organic acids (1% solution), were chromatographed at the points where these lines cut the small circle. In the centre of the circle, an aperture of 0·4 mm. diameter was made and a wick of 1·5 cms. height made of the same filter paper was inserted in the aperture.

The paper was equibrated at room temperature (20-21° C) for 24 hrs. by placing a small amount of the lower layer of n-butanol-formic acid-water (10 : 2 : 5v/v ; Kalyankar et al -4). A few c.cs of the upper layer of the above mixture, which served as the solvent phase, were placed in the petri dish. The paper after equibration was supported on the circular ring with the paper wick dipping in the developing solution of the petri dish. The glass trough was covered with a circular glass plate having a diameter of 38 cms.

The chromatograms, after developing for 5-7 hours, were first air-dried overnight at room temperature and then again dried in an electric oven for about one hour at 75-80° C. The acids were located as lemon yellow spots on the chromatograms by spraying the paper with bromo-phenol blue (0·08 gms in 100 ml of 95 % ethanol).

The R_f values of acids used are recorded in table no. 1. The non-volatile acids found in different plants are given in table no. 2.

Table No. 1

R_f Values of acids

Name of acids	R_f value
Gluconic acid	0·18
Tartaric ,,	0·35
Oxalic ,,	0·40
Citric ,,	0·56
Malic ,,	0·62
Citraconic ,,	0·65
Succinic ,,	0·79
Fumaric ,,	0·90

Table No. 2

Acids detected in plants

Botanical name	Acid contents
Valeriana wallichii (local-name Samyo)	Tartaric, Citric, Malic & Succinic.
Osimum Scantum (Tulsi)	Citric, Tartaric & Malic.
Roscoea procera (Musli)	Citric, Malic & Succinic.
Satyrium napalensis (Salam-misri)	Citric & Malic.
Saxifraga diversifolia (Pather Chatta)	Tartaric & Malic.
Puraria tuberosa	Gulconic & Malic.
Arisaema curvatum (Snake plant)	Malic only.

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KINETICS OF OXIDATION OF KETONES BY PERSULPHATE ION

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Introduction

The kinetics of oxidation of acetone by potassium persulphate catalysed by Ag$^{\cdot}$ ion was studied by Bekier and Kijowski[1] and they proposed a mechanism for this reaction based on the general mechanism of Yost[2] for Ag...catalysed reactions of persulphate ion according to which the rate determining step consists in the oxidation of Ag$^{\cdot}$ to trivalent Ag$^{\cdots}$ ion. However, this mechanism is not in line with the general theory of redox reactions given by Haber and Weiss[3] according to which redox reactions proceed stepwise and often consist of simple electron transfer processes. Srivastava and Ghosh[4] have, as the result of their study of the kinetics of Ag$^{\cdot}$ catalysed reaction between H_2O_2 and $K_2S_2O_8$, proposed an alternative general mechanism for the Ag$^{\cdot}$ catalysed oxidation reactions of persulphate ion according to which it is postulated that the rate determining step for such reactions consists in the oxidation of Ag$^{\cdot}$ to bivalent Ag$^{\cdots}$ and not trivalent Ag$^{\cdots}$, as proposed by Yost (loc-cit). Hence interest was aroused in the investigation of the kinetics of oxidation of acetone and other ketones by persulphate ion, firstly, to verify if the general mechanism proposed by Srivastava and Ghosh (loc. cit.) for the Ag$^{\cdot}$ catalysed reactions holds good in this case or not and secondly to determine the nature of the uncatalysed oxidation of acetone by $K_2S_2O_8$ and thereby find out if the general mechanism proposed by Srivastava and Ghosh[5] for the uncatalysed oxidation reactions of persulphate ion wherein it is proposed that the primary process is the breaking of persulphate ion into one sulphate ion (SO_4'') and one sulphate radical (SO_4) which combine by a slow process to form two sulphate radical ions (SO_4') holds good for this reaction also.

The present paper deals with the kinetic study of the Ag$^{\cdot}$ catalysed as well as uncatalysed oxidation of acetone by $K_2S_2O_8$. The Ag$^{\cdot}$ catalysed oxidation of other ketones and formaldehyde by $K_2S_2O_8$ has also been investigated. The kinetics of Ag$^{\cdot}$ catalysed oxidation of other ketones and formaldehyde and the kinetics of the uncatalysed oxidation of acetone by persulphate ion have been studied for the first time by us.

Experimental

Potassium persulphate G. R. E. Merck quality and acetone A.R.B.D.H. quality were used throughout the work. All other reagents used were of A.R.B.D.H. quality. As the reactions of potassium persulphate are known to be susceptible to traces of impurities, great care was taken to ensure that the highest standard of purity is maintained, and, therefore, redistilled water from a pyrex distilling still was always used.

It was seen that the reaction in the absence of any catalyst was very very slow at ordinary temperature. However, in the presence of 0·0005M $AgNO_3$ as catalyst the reaction had a measurable velocity at 35°C and therefore the reaction was carried out at 35°C in the presence of this concentration of $AgNO_3$ as catalyst. However, a higher temperature of 55°C was employed for studying the kinetics of the uncatalysed reaction.

A pyrex bottle coated on the outside with black-japan and covered with black cloth was used as the reaction bottle. A standard solution of $K_2S_2O_8$ was freshly prepared (daily) by direct weighing of the calculated amount of $K_2S_2O_8$ and dissolving in redistilled water and making up the solution in a measuring flask. The strength of $K_2S_2O_8$ solution was checked by iodometric estimation. The standard solution of acetone or other ketones was prepared by taking calculated volume of the substance and making up the solution with redistilled water in a measuring flask. The reaction was carried out by running in calculated volume of $K_2S_2O_8$ solution into the reaction vessel containing the other reactants, immersed in a thermostatic water bath with an accuracy of ±0.1°C. At suitable intervals of time 10 cc of the reaction mixture was estimated for the amount of $K_2S_2O_8$ remaining unreacted in the following manner. The reaction mixture was added to an ice cooled mixture of $CuSO_4$, $FeSO_4$ and KI in an iodine flask of the following composition.

1% $CuSO_4$—1 cc, 1% $FeSO_4$—1 cc, 10% KI—10 cc,

After allowing 2-3 minutes for the liberation of iodine, the liberated iodine was estimated against a standard solution of sodium thiosulphate with a microburette using starch solution as an indicator. It was found that the titration was fairly rapid and the results obtained reproducible. The volume of $Na_2S_2O_3$ corresponding to iodine liberated by $K_2S_2O_8$ and thereby its concentration was obtained after deducting the volume of $Na_2S_2O_3$ corresponding to iodine liberated by $CuSO_4$.

This iodometric method of the estimation of persulphate is a modification of the method given by Gopala Rao and coworkers[6], wherein they have used a mixture of ferrous sulphate and cuprous iodide as the catalyst for the oxidation of KI by S_2O_8''. Szabo, Csanyi and Galiba[7] have proposed the use of a mixture of $CuSO_4$ and $FeSO_4$ as the catalyst for this estimation and their method, with slight modification in concentrations has been employed by us.

RESULTS OF THE MEASUREMENTS

Ag^+ Catalysed reaction—First of all, the reaction was carried out in the presence of $AgNO_3$ as catalyst at the following concentration:

Table No. I

Reaction Mixture		*Temperature 35°C*
Total volume—200 c.c.		Over all concentration
4% Acetone	= 20 c.c.	0.8%
0.08M $K_2S_2O_8$	= 50 c.c.	0.02M
0.01M $AgNO_3$	= 20 c.c.	0.001M
Water	=110 c.c.	

Time in minutes	Volume of N/100 $Na_2S_2O_3$ in c. c.	Volume of $Na_2S_2O_3$ corresponding to $K_2S_2O_8$ Concentration	$K \times 10^3$ (unimolecular)
10	23.25	19.25	3.8229
30	21.85	17.85	3.7922
40	21.40	17.40	3.7332
80	19.95	15.95	2.8269
120	18.20	14.20	2.8538
180	16.25	12.25	2.7238
220	14.90	10.90	2.7594
240	14.30	10.30	2.7258

A fair constancy of the unimolecular constant leads to the conclusion that the reaction is probably unimolecular with respect to $K_2S_2O_8$, since acetone has been taken in excess. In order to confirm this, the reaction was carried out at other initial concentrations of $K_2S_2O_8$, keeping the concentration of acetone and $AgNO_3$ constant and the results are represented in the graph Nos. 1 and 2. From the curves the time for the same fraction ($\frac{1}{4}$) to decompose is read out which come out to be 104, 109 and 104 minutes which is approximately constant leading to the conclusion that the reaction is unimolecular with respect to persulphate ion. Bekier and Kijowski (loc. cit) have also reported unimolecularity of the reaction with respect to persulphate ion.

In order to derive the relationship between the rate of the reaction and the concentration of acetone, the reaction was carried out at equimolecular concentration of acetone and $K_2S_2O_8$, the results of which are recorded below :—

Table No. II

Reaction Mixture *Temperature 35°C*

		Over all concentration
	Total volume=200 c.c.	
0.01M Silver nitrate	=10 c.c.	0.0005M
0.1M Acetone	=20 c.c.	0.01M
0.1M Potassium persulphate	=20 c.c.	0.01M
Water	=150 c.c.	

Time in minutes	Volume of N/100 $Na_2S_2O_3$ in c. c.	Volume of $Na_2S_2O_3$ corresponding to $K_2S_2O_8$ Concentration	$K \times 10^3$ (unimolecular)
0	24.00	20.00	——
10	23.45	19.45	2.7866
40	22.00	18.00	2.6312
80	20.45	16.45	2.4441
140	18.25	14.25	2.4231
180	16.90	12.90	2.4361
220	15.85	11.85	2.3749
260	15.00	11.00	2.2994
280	14.70	10.70	2.2307

Thus it is seen that at equimolecular concentrations of $K_2S_2O_8$ and $CH_3.CO.CH_3$ also the reaction is unimolecular, which leads to the conclusion that the reaction rate is independent of the concentration of the reducing substance—acetone. It may be pointed out that this is also true of other reactions of persulphate ion (c. f. the effect of HCOO′ concentration on $K_2S_2O_8$—HCOOK reaction studied by Srivastava and Ghosh[8] and effect of H_2O_2 concentration on $K_2S_2O_8$—H_2O_2 reaction)[9].

In order to decide the role of the catalyst $AgNO_3$ on the kinetics of this reaction, different concentrations of $AgNO_3$ were used in different experiments, results of which are summarised below :—

Table No. III

$K_2S_2O_8=0.01M$ Acetone=0.8% Temperature=35°C

Concentration of $AgNO_3$	Mean value of K unimolecular
0.0005M	2.2817×10^{-3}
0.0010M	2.9341×10^{-3}
0.0015M	5.3841×10^{-3}

Salt Effect—In order to determine the effect of the change of ionic strength on the rate of reaction, the reaction was carried out in the presence of different concentrations of added K_2SO_4 as salt. The results obtained at different salt concentrations are summarised below :—

Table No. IV

$K_2S_2O_8=0{\cdot}01M$, Acetone=0.8%, $AgNO_3$—0.0005M, Temp. 35°C

Concentration of K_2SO_4	μ	$K\times10^3$	Log K	$(\mu)^{\frac{1}{2}}$
0.00	0.025	2.2817	−2.6419	0.1581
0.01	0.050	1.7935	−2.7464	0.2236
0.02	0.075	1.6736	−2.7765	0.2739
0.03	0.100	1.5822	−2.8003	0.3169

When the values of log K are plotted against $\mu^{\frac{1}{2}}$, the curve thus obtained (graph No. 3) is approximately a straight line showing that the salt effect is negative and is of the primary exponential type.

When the reaction is carried out in presence of Na_2SO_4 as added salt instead of K_2SO_4, the mean value of the rate constant is 1.9951×10^{-3} in presence of 0.01M Na_2SO_4, while at equimolecular concentration of K_2SO_4, the value of the rate constant is 1.7935×10^{-3}. Thus it seems that the reaction shows beside general salt effect, specific in-hibitory effect of ions, the effect of K^+ ions being more than that of Na^+. (c. f. the effect of K^+ ions on $K_2S_2O_8$—HCOOK reaction studied by Srivastava and Ghosh (Loc. cit).

Reduction of formaldehyde and other ketones—In order to compare the reactivity of formaldehyde and other ketones with acetone regarding their reducing power, the reaction was carried out with the same concentration of formaldehyde and other ketones in different experiments. It was found that the general character of the reaction remains the same, the reaction being unimolecular in each case. Further, it is seen that the reducing power of formaldehyde is the greatest while the reducing power of the ketones goes down as we go up the homologous series.

Uncatalysed reaction —The following table records the results obtained in the absence of $AgNO_3$ as catalyst at a temperature of 55°C:

Table No. V

Reaction Mixture	*Temperature* 55°C Over all concentration.
Acetone	0.8%
$K_2S_2O_8$	0.01M

$\mu = 0.025$

Time in minutes	Volume of N/50 $Na_2S_2O_3$ in c. c.	Volume of $Na_2S_2O_3$ corresponding to $K_2S_2O_8$ Concentration	$K \times 10^3$ (unimolecular)
0	11.85	9.85	——
10	11.79	9.79	0.59878
40	11.62	9.62	0.58724
60	11.51	9.51	0.58342
120	11.18	9.18	0.58726
180	10.88	8.88	0.57575
240	10.63	8.63	0.55080
300	10.36	8.36	0.54658
360	10.11	8.11	0.53992
420	9.85	7.85	0.54010

It is seen that the reaction is unimolecular in the absence of the catalyst also. However it is found that the reaction even at 55°C is rather very slow—1/5th of reaction taking place in about 7 hours' time. In order to decide the nature of the rate determining step for the uncatalysed reaction, the reaction was carried at different ionic strengths by addition of different concentrations of K_2SO_4, the results being summarised in the following table:—

Table No. VI

Concentration of K_2SO_4	μ	$K \times 10^3$	$(\mu)^{\frac{1}{2}}$	Log K
0.00M	0.025	0.5626	0.1581	-3.2498
0.01M	0.050	0.3375	0.2236	-3.4718
0.02M	0.075	0.2619	0.2739	-3.5819
0.04M	0.125	0.2118	0.3536	-3.6714

On plotting $(\mu)^{\frac{1}{2}}$ against Log K (graph No. 4) the curve is not linear, indicating that the negative salt effect obtained is not of the primary exponential type. When the ionic strength μ is plotted against K (graph No. 5) the curve is again not linear, indicating that the negative salt effect is also not of the linear type. Because the uncatalysed reaction is unimolecular in behaviour, a primary linear salt effect, if any, could be possible, but it is not borne out by experiment. Probably a more detailed and careful study of the uncatalysed reaction is necessary, before the nature of the salt effect can be determined with accuracy.

DISCUSSION

Thus we find that the reaction between potassium persulphate and acetone is unimolecular with respect to S_2O_8'' and zeromolecular with respect to acetone. For the Ag^+ catalysed reaction, a negative exponential salt effect is obtained which shows that the rate determining step is the reaction between two oppositely charged ions. The Ag^+ catalysed reaction, therefore, probably follows the mechanism as outlined below:—

$$S_2O_8'' + Ag^+ \xrightarrow[\text{determining}]{\text{rate}} SO_4' + SO_4'' + Ag^{++} \qquad \text{.........(i)}$$

$$SO_4' + H_2O \xrightarrow{\text{rapid}} HSO_4' + OH \qquad \text{.........(ii)}$$

$$OH + Ag^{++} \xrightarrow{\text{rapid}} Ag^+ + OH^+ \qquad \text{.........(iii)}$$

$$OH^+ + CH_3COCH_3 \longrightarrow \text{Products.} \qquad \text{.........(iv)}$$

The above mechanism is on the lines of the general mechanism proposed by Srivastava and Ghosh (Loc. cit) for the Ag^+ catalysed oxidation reactions of persulphate ion.

In the case of the uncatalysed reaction, the exact nature of the negative salt effect observed by us could not be definitely decided. However, since the uncatalysed reaction is unimolecular, the negative exponential salt effect can only be present if the rate determining process is between two oppositely charged ion, one of which is present at constant concentration throughout the course of the reaction, which is rather improbable. Therefore, the only logical conclusion is that the salt effect is probably linear in nature and is due to the rate determining process being between a charged ion and a neutral substance. If this be the case, the mechanism for the uncatalysed reaction is probable as follows:—

$$S_2O_8'' \xrightarrow[\text{equilibrium}]{\text{rapid}} SO_4 + SO_4'' \qquad \ldots \quad \ldots \quad \text{(i)}$$

$$SO_4 + SO_4'' \xrightarrow[\text{determining}]{\text{rate}} 2SO_4' \qquad \ldots \quad \ldots \quad \text{(ii)}$$

$$2SO_4' + H_2O \xrightarrow{\text{rapid}} OH^+ + HSO_4' + SO_4'' \quad \ldots \quad \text{(iii)}$$

$$OH^+ + CH_3COCH_3 \xrightarrow{\text{rapid}} \text{Products} \quad \ldots \quad \ldots \quad \text{(iv)}$$

The above mechanism for the uncatalysed reaction is also on the lines of the general mechanism proposed by Srivastava and Ghosh (Loc cit) for the uncatalysed oxidation reactions of persulphate ion.

When the rates of oxidation of formaldehyde and other ketones are considered, it is seen that the rate in the case of formaldehyde is the highest and it goes down as one passes from one ketone to a higher ketone. However, in each case the reaction remains unimolecular and the value of the rate constant is of the same order. This leads to the conclusion that the oxidation of formaldehyde and different ketones by persulphate ion follow the same mechanism.

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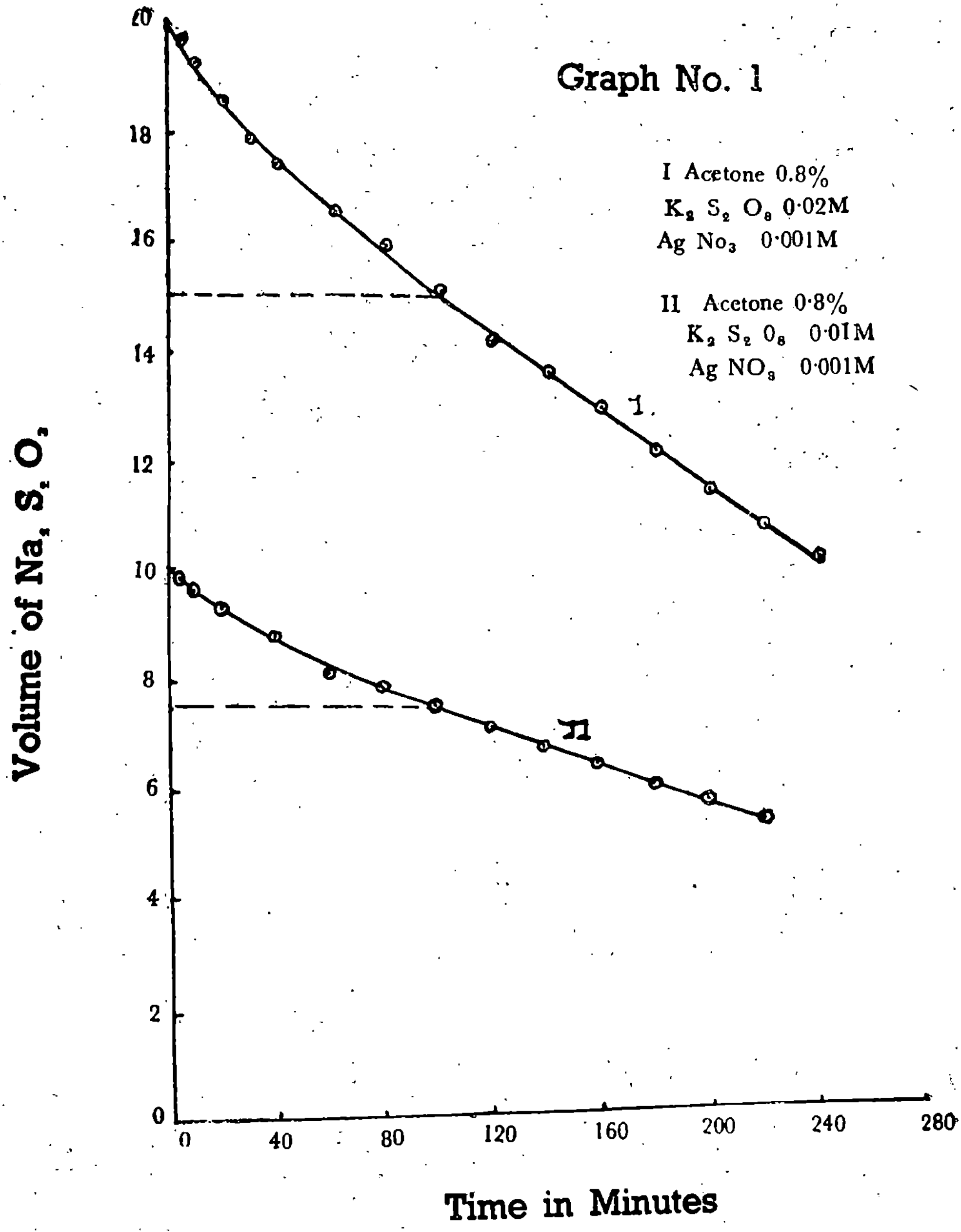
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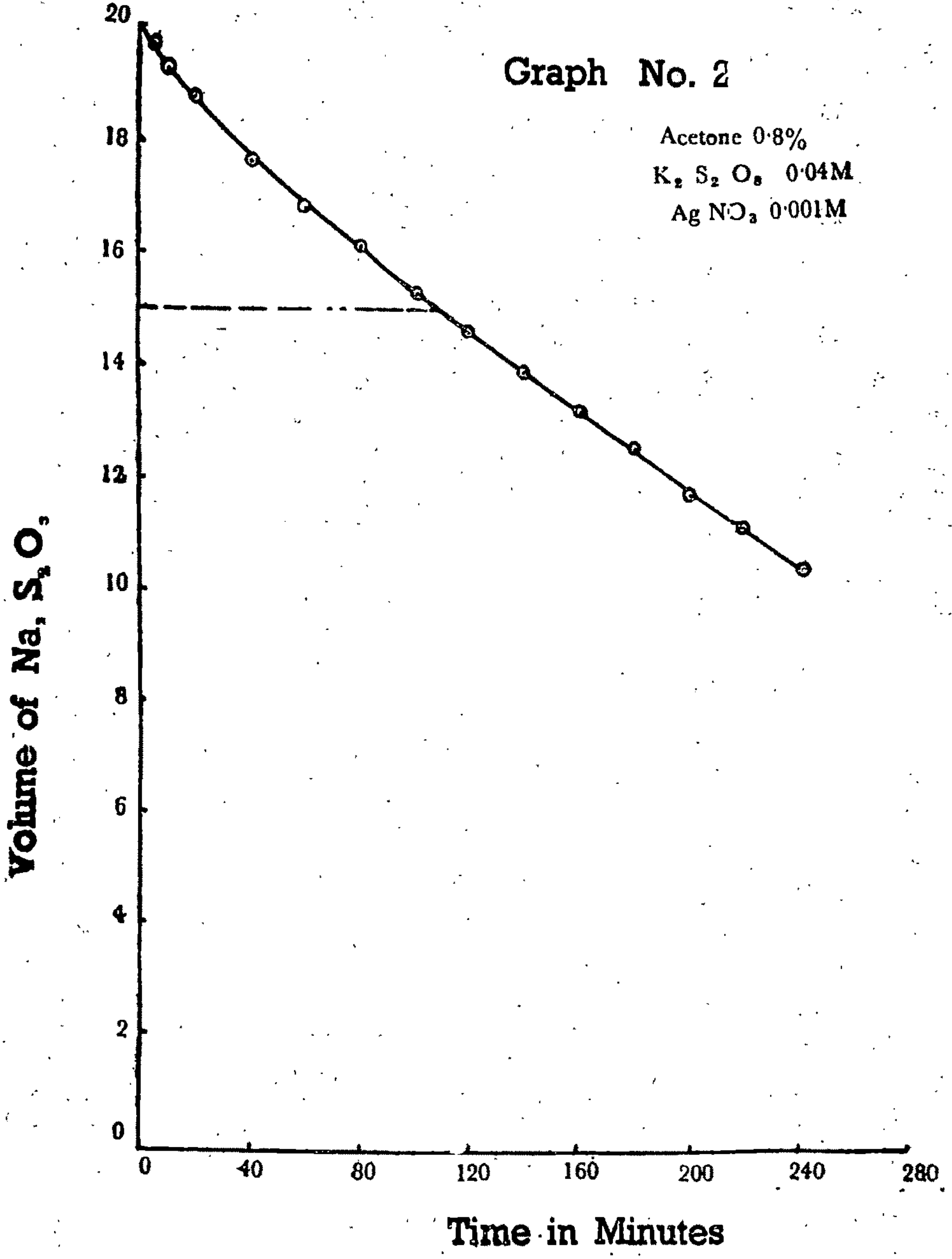
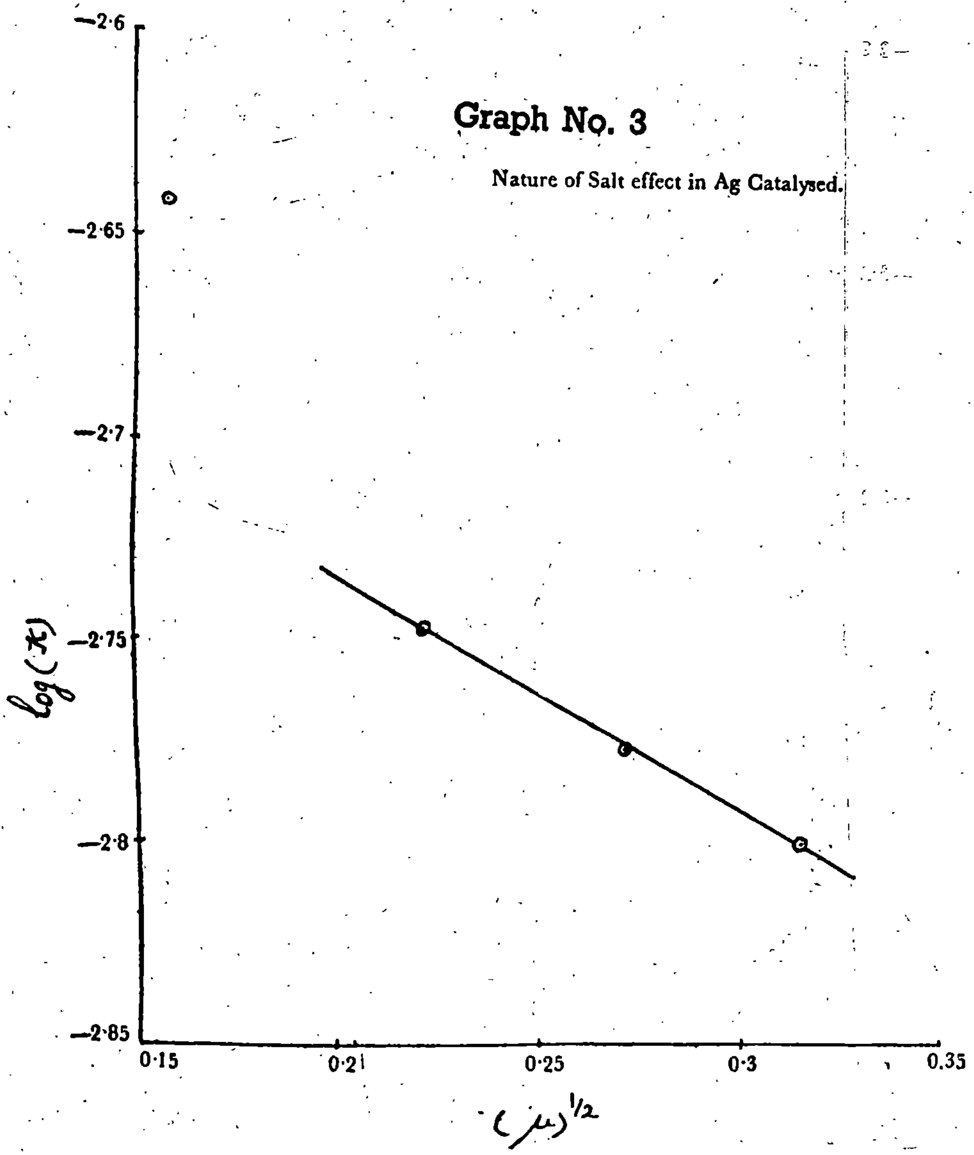
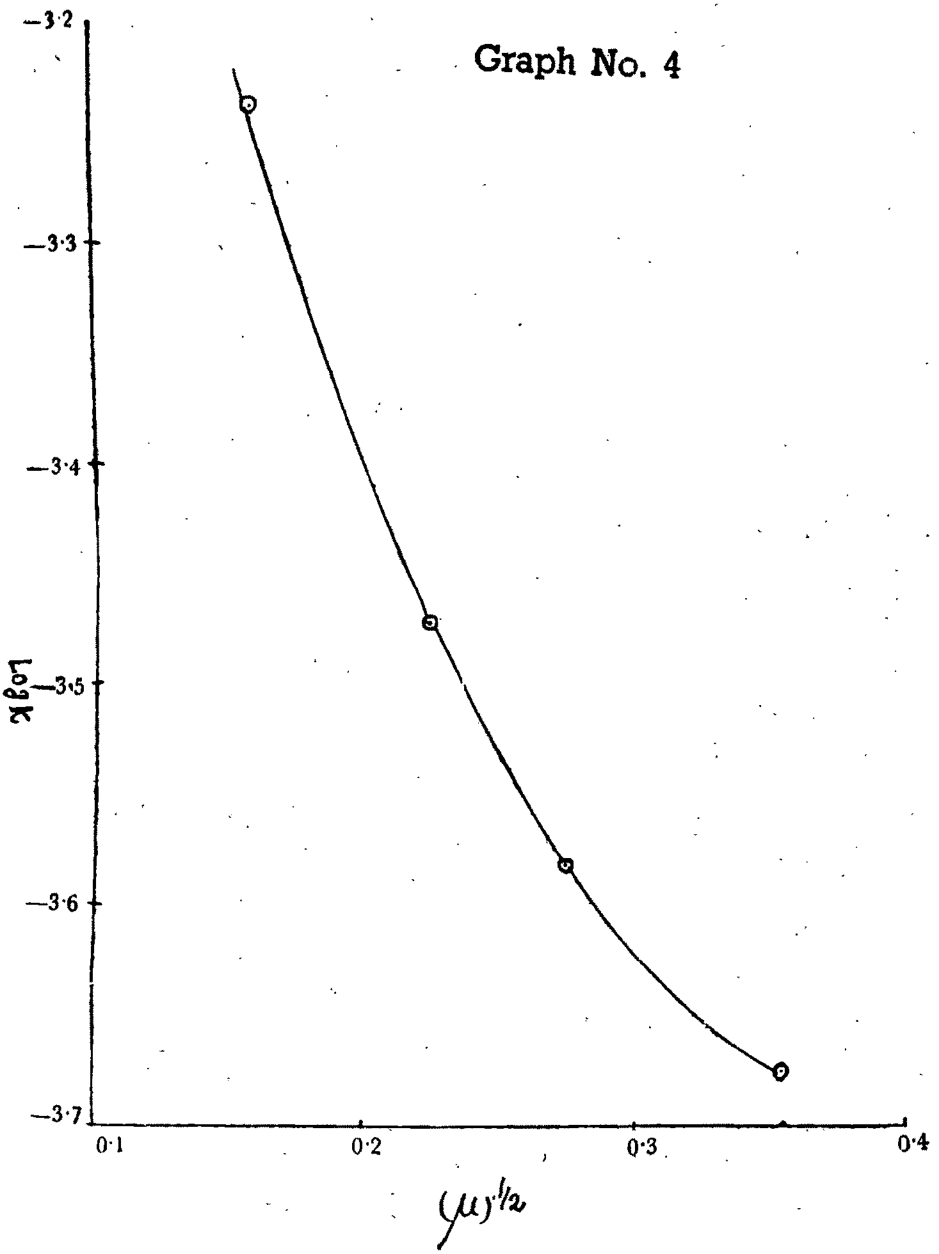
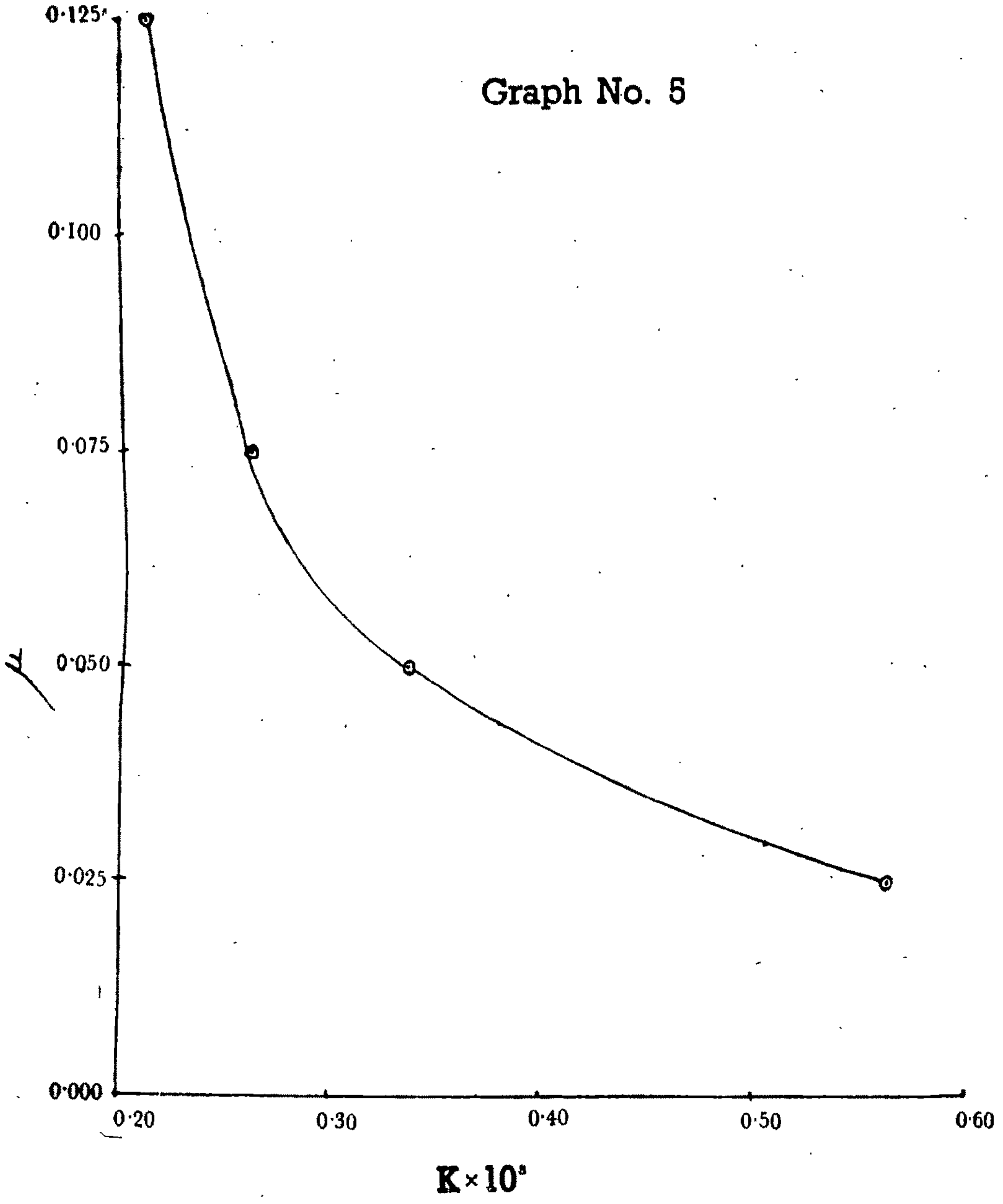
I Acetone 0.8%
$K_2 S_2 O_8$ 0·02M
Ag No_3 0·001M
II Acetone 0·8%
$K_2 S_2 O_8$ 0·01M
Ag NO_3 0·001M
I
II
Volume of $Na_2 S_2 O_3$
20
18
16
14
12
10
8
6
4
2
0
0
40
80
120
160
200
240
280
Time in Minutes


Graph No. 2
Acetone 0·8%
$K_2 S_2 O_8$ 0·04M
$AgNO_3$ 0·001M
Volume of $Na_2 S_2 O_3$
Time in Minutes
20
18
16
14
12
10
8
6
4
2
0
0
40
80
120
160
200
240
280


Graph No. 3
Nature of Salt effect in Ag Catalysed.
log (k)
−2·6
−2·65
−2·7
−2·75
−2·8
−2·85
0·15
0·21
0·25
0·3
0.35
$(\mu)^{1/2}$


Graph No. 4
−3·2
−3·3
−3·4
−3·5
−3·6
−3·7
Log K
0·1
0·2
0·3
0·4
$(\mu)^{1/2}$


Graph No. 5
0·125
0·100
0·075
0·050
0·025
0·000
μ
0·20
0·30
0·40
0·50
0·60
K × 10³

CHROMATOGRAPHIC CHARACTERIZATION OF AMINO-ACIDS IN SOME COMMON VEGETABLES OF NAINI TAL

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Vegetables form a major part of our daily diet. Free amino acids present in a number of common vegetables grown in this region have been characterized with a view to finding their relative importance in diet from nutritional point of view.

EXPERIMENTAL

The vegetables were crushed in a pestle and mortar, and the solutions centrifuged at 4000 r.p.m. for 10-15 minutes. The solid suspending material settled at the bottom, and the clear supernatent liquid was decanted and used for the characterization of amino acids.

In some cases, where a particular vegetable was not juicy, a small amount of distilled water was added, it was then crushed and centrifuged. The concentration of the extract was adjusted by trial. Circular paper chromatographic technique was employed. The details of the apparatus have been described in an earlier communication (1).

The extracts of vegetables and reference amino acids (0·1 % solution) were chromatographed together on Whatman filter paper No. 1. The upper layer of butanol-acetic acid-water (4 : 1 : 5v/v; partridge 1948.) was used as the solvent phase. The chromatograms after development for 5-6 hours at 18-20° C were air dried over-night and then again dried in an electric oven at 65° C for 10-15 minutes. The chromatograms after drying were sprayed with 0·1 % solution of ninhydrin in acetone. The amino acids were located as pink spots.

The chracterization of amino acids in the extracts of vegetables was not confirmed merely by comparing the R_f values of the amino acids present with those of the reference amino acids, as the R_f values of amino acids present in the extracts might be affected due to the presence of other minor constituents in the extracts and hence they may be slightly different from those of the reference amino acids. The extracts of vegetables and the solution of standard amino acids were chromatographed together. It was observed that the amino acids present in the extracts and the reference amino acids moved exactly to an equal distance on the paper from the line of application. It was, therefore, evident that the movement of amino acids and hence their R_f values are not affected by the presence of other natural products present in the extracts. It was, therefore, thought unnecessary to separate these amino acids from other constituents present in the extracts.

The R_f values of cystine, arginine, lysine, ornithine, histidine, serine, aspartic acid, glycine, glutamic acid, alanine, tyrosine, methionine, valine, tryptophan, phenyl-alanine, isoleucine, and leucine were determined and were found to be ·06, ·07, ·08, ·09, ·12, ·14, ·16, ·18, ·208, ·26, ·41, ·44, ·48, ·51, ·65, ·70, and ·74 respectively.

The amino acids found to be present in 15 common vegetables have been recorded in the following table :

S.N.	Name	Botanical Name	Amino Acids
1.	Cabbage	Brassica oleracea var capitater.	glutamic, alanine, valine, tyrosine, phenyl-alanine.
2.	Spinach.	Spinacia oleracea.	alanine, aspartic, serine.
3.	Pea.	Psium sativum.	aspartic, tyrosine, valine.
4.	Tomato.	Lycopersicum esculentum.	glumatic, aspartic, alanine, tyrosine.
5.	Radish.	Raphanus sativus.	alanine, aspartic.
6.	Spinach type.	Rhubarb rheum officinale.	alanine, glutamic.
7.	French bean	Phaseolus vulgaris.	alanine, glutamic, valine, tyrosine, phenyl-alanine.
8.	Bitter gourd	Cylenthera pedata.	tyrosine, histidine, glycine.
9.	Onion.	Allium cepa.	aspartic, lycine, alanine, glutamic.
10.	Garlic	Allium sativum.	aspartic, leucine, valine.
11.	Methi	Trigonella foenumgraecum	valine, alanine, serine, tyrosine.
12.	Coriander.	Coriandrum sativum.	glutamic, valine, phenyl-alanine.
13.	Mint.	Mentha sylvestris	histidine, glycine.
14.	Chilli.	Capsicum annum.	glutamic, alanine, tyrosine, phenyl-alanine.
15.	Lemon.	Citrus medica var Limon	glutamic, alanine.

Thus they are good sources of essential and non-essential amino acids.

Further work is in progress to characterize other organic compounds present in the extracts of these vegetables.

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PHYSIOLOGICAL STUDIES ON SALT TOLERANCE IN CROP PLANTS. VII STUDIES ON GROWTH AND MATURITY OF WHEAT AND GRAM IN SALINE OR ALKALINE AREAS IN CULTIVATORS' FIELDS*

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Introduction

It is generally known that excessively saline ('White alkali') or alkaline ('Black alkali') lands are not fit for cultivation. It has also been observed that cultivated fields near such areas often show patchy growth of crop plants. The patches may even become barren due to failure of germination or to early seedling mortality. They gradually spread out, finally covering the whole field.

According to soil scientists, deterioration of the soil in such areas starts with an accumulation of soluble salts (mostly chlorides and sulphates) in the root-zone. Gradually Na-content of the soil increases and carbonates appear, chiefly as sodium carbonate. The pH, which was initially near about 7 gradually increases to 8 or more, making the soil alkaline. During the later stages, due to increase in Na-content, the soil structure is altered as a result of the deflocculation of the soil particles. A hard pan in the subsoil (at a depth of about one foot or even less) is a common feature at this stage which interferes with percolation of water, soil aeration and root penetration.

According to Hayward and Wadleigh (1949) soils are grouped as follows :

(1) Alkali soil : With sufficient exchangeable Na to interfere with the growth of crop plants, and with or without appreciable quantities of soluble salts.

(a) Non-saline alkali soil : Exchangeable Na percentage is greater than 15 ; does not contain appreciable quantities of soluble salts ; pH 8.5-10.

(b) Saline-alkali soil : Similar to above but with appreciable quantities of soluble salts.

(2) Saline soil : Contains enough soluble salts to check the growth of plants ; exchangeable Na percentage is less than 15 and pH is less than 8.5.

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Even moderately saline soils are known to be harmful to growth of crop plants. Alkali soils are definitely injurious to legumes (Russel 1950). Detailed investigation on relative tolerance of crop plants to salinity and alkalinity have been in progress at the U.S.Regional Salinity Laboratories since about two decades. In India, although generalised statements are available regarding suitability of various crops *e.g.*, rice to saline or alkaline areas, quantitative studies even on yield are scarcely available for different crops grown on moderately saline or alkaline lands.

The present investigation was undertaken to compare the growth and maturity of the two important rabi crops, wheat and gram, in 'good' and 'bad' (saline or alkaline) areas in cultivators' fields. Soil samples (0-6″ layer) were collected from these areas and their chemical analysis and other characters were also studied in order to assess the normal, saline or alkaline nature of the soil in the areas under study.

Besides the above study, germination and seedling growth (upto 8 week stage) of wheat and gram was studied in pots filled with soil (0-6″ layer) from 'good' and 'bad' areas of cultivators' fields. The object was to eliminate the soil-moisture variations which may occur in these 'good' and 'bad' areas in cultivators' fields.

METHODS AND MATERIALS

During rabi 1953-54 and 1954-55, saline and alkaline areas were selected from cultivator's fields with wheat and gram crops ; the selection was based on visual observations. The alkaline field contained barren alkali parches, crop growth was poor around the patches and improved farther away ; while in saline field barren patches were not seen but distinct areas of good and poor growth of the crop plants were evident.

20 random plants, each from relatively 'good' and 'bad' areas in saline and alkaline fields, of wheat and gram were harvested at maturity, and observations on their height, number of leaves and tillers or branches, spike length in wheat, shoot-dry-weight (minus grain or seed), yield of grain or seed and 100-grain or seed-weight of the the same were recorded. 'Standard errors' were calculated so as to indicate variations within each area, and are included along with the 'means'. Soil samples, from the surface layer (0—6″) were collected from the same areas and, according to A.O.A.C., methods adopted by Piper (1946), estimations were made on the samples in duplicates for total soluble salts, chlorides, carbonates and bicarbonates. pH was estimated by a colour comparator.

Soil samples (0—6″ layer) from 'good' and 'bad' areas of saline and alkaline fields were collected again during rabi 1955-56. Germination and seedling growth (upto 8 week stage) of wheat C.591 and gram N.P.28 were studied in pot cultures in soils collected from the above areas, in order to eliminate the soil moisture variations occuring under natural conditions in the fields. Duplicate pots were kept for each soil and crop; 10 seeds were sown per pot, and four weeks after sowing, seedlings were thinned to five. Observations on germination (six and nine days after sowing), height of the main-shoot, number of fully open green leaves and of tillers or branches, and shoot-dry-weight at four and eight weeks after sowing were recorded. Here too, the soil samples were analysed initially, in duplicates, for total soluble salts, chlorides, carbonates, bicarbonates and pH.

The pots were watered frequently, the leachates were returned to the pots but unfortunately the plants could not be grown to maturity in all cases due to excessive compacting of the 'bad' soil in pots leading to poor growth of the plants.

It should be noted that the 'good' and 'bad' areas were selected from the same field and also as close to one another as possible, *i.e.*, fairly adjacent to each other to avoid other environmental variations.

RESULTS

Comparison is made between the chemical composition of the soils and the plant growth of the crops under study.

(A) Influence of soil salinity and alkalinity on growth and maturity of wheat and gram in cultivators' fields.

(a) Influence of soil salinity :-

Table No. I

Influence of soil salinity on growth and maturity of wheat

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Saline area ('Bad')	Normal area ('Good')	Saline area ('Bad')
Soil characters :— Total soluble salts (mg/100 gm soil)	67	200	65	210
Chlorides (mg/100 gm soil)	5	20	10	20
Carbonates (mg/100 gm soil)	—	—	—	—

(*Contd.*)

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Saline area ('Bad')	Normal area ('Good')	Saline area ('Bad')
Bicarbonates (mg/100 gm soil)	40	72	18	60
pH	7.2	7.2	7.2	7.2

Crop characters (Mean per plant) :—

Height (cm)	97.0 ±1.8	82.3 ±2.3	100.0 ±2.0	82.0 ±2.3
Leaves (No)	34.6 ±1.8	23.9 ±1.8	35.0 ±2.0	24.0 ±1.9
Tillers *i.* Mature (No)	9.4 ±0.5	6.4 ±0.5	9.6 ±0.5	6.0 ±0.6
ii. Immature (No.)	2.1 ±0.15	1.4 ±0.35	2.2 ±0.20	1.4 ±0.20
Spike length	8.3 ±0.20	6.5 ±0.20	8.0 ±0.25	6.3 ±0.20
Shoot-dry-weight (gm)	10.9 ±0.50	4.2 ±0.37	11.0 ±0.5	4.0 ±0.35
Grain-Yield (gm)	7.2 ±0.40	2.1 ±0.17	7.3 ±0.40	2.1 ±0.16
100 grain weight (gm)	3.5 ±0.06	3.1 ±0.08	3.6 ±0.07	3.1 ±0.09

Table II

Influence of soil salinity on growth and maturity of gram

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Saline area ('Bad')	Normal area ('Good')	Saline area ('Bad')
Soil characters :				
Total soluble salts	133	333	150	260
Chlorides	20	20	17	26
Carbonates	—	—	—	—
Bicarbonates	48	95	53	44
pH	7.4	7.6	7.2	7.2
Crop characters (Mean per plant) :				
Height (cm)	50.5 ±1.0	28.3 ±0.9	56.0 ±2.0	33.3 ±1.5
Leaves (No)	272.5 ±15.6	75.2 ±4.9	332.5 ±17.1	102.1 ±4.4
Branches (No)	48.0 ±2.8	11.0 ±0.7	31.7 ±1.0	9.3 ±0.6
Shoot-dry-weight (gm)	13.0 ±0.80	1.8 ±0.19	10.0 ±0.54	1.7 ±0.13
Seed Yield (gm)	7.0 ±0.50	1.0 ±0.17	8.6 ±0.60	1.3 ±0.13
100-seed-weight (gm)	7.1 ±0.26	6.0 ±0.59	12.7 ±0.36	9.9 ±1.5

The data on soil analysis indicate (Tables I & II) that in relatively bad (saline) areas, the soil contains higher amounts of total soluble salts, particularly chlorides and bicarbonates. Carbonates are, however, absent in both 'good' and 'bad' areas and pH is not altered.

Depressing influence of soil salinity on plant growth is clear from tables I & II. The values for all the characters under study are lowered for the saline area ; the height of the plants of wheat was lowered to a lesser extent than that in gram, and similar was the case for shoot-dry-weight and the yield. The percentage reduction in each case from the respective control (relatively 'good' area) are given in Table III.

Table III

Influence of soil salinity on growh and yield of wheat and gram
(Percentage on respective controls)

Observation	Wheat			Gram		
	1953-54	1954-55	Average	1953-54	1954-55	Average
Height	15	18	16	44	40	42
Shoot-dry-weight	61	64	63	86	83	85
Grain or seed-yield	71	71	71	86	85	86

It is clear that in wheat although a small decrease in the height of the plants was noted, yet the decrease in shoot-dry-weight and grain-yield was considerable ; in gram the adverse effect of soil salinity was more pronounced than in wheat.

(b) Influence of soil alkalinity :

Table IV

Influence of soil alkalinity on growth and maturity of wheat

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Alkaline area ('Bad')	Normal area ('Good')	Alkaline area ('Bad')
Soil characters :—				
Total soluble salts	267	167	150	110
Chlorides	20	10	23	36
Carbonates	—	13	—	9
Bicarbonates	48	43	62	35
pH	7.4	8.2	7.2	8.2

(*Contd.*)

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Alkaline area ('Bad')	Normal area ('Good')	Alkaline area ('Bad')
Crop characters (Mean per plant):				
Height (cm)	118 8 ±1.8	62.0 ±1.5	86.3 ±1.3	52.0 ±2.0
Leaves (No)	32.9 ±1.9	5.7 ±0.3	30.7 ±1:3	18.8 ±0.7
Tillers i. Mature (No)	5.8 ±0.4	1.2 ±0.1	4.4 ±0.2	1.5 ±0.2
ii. Immature (No)	1.9 ±0.15	0.6 ±0.05	3.1 ±0.20	2.0 ±0.20
Spike length (cm)	10.8 ±0.20	5.8 ±0.25	8.3 ±1.15	6.3 ±0.13
Shoot-dry-weight (gm)	9.1 +1.6	1.1 ±0.1	8.8 ±0.6	1.7 ±0.2
Grain-Yield (gm)	6.3 ±0.68	0.4 ±0.04	4 6 ±0.35	0.6 ±0.09
100-grain-weight (gm)	2.7 ±0.16	2.0 ±0.12	3.3 ±0.10	2.1 ±0.15

Table V

Influence of soil alkalinity on growth and maturity of gram

Season	1953-54		1954-55	
Observation	Normal area ('Good')	Alkaline area ('Bad')	Normal area ('Good')	Alkaline area ('Bad')
Soil characters :				
Total soluble salts	133	167	150	160
Chlorides	30	40	20	36
Carbonates	—	23	—	9
Bicarbonates	48	91	62	35
pH	7.2	8.2	7.2	8.0
Crop characters (Mean per plant) :				
Height (cm)	45.5 ±0.8	20.3 ±0.9	60.3 ±1.5	28.0 ±0.8
Leaves (No)	257.7 ±22.8	47.9 ±2.4	302.7 ±25.1	115.8 ±11.0
Branches (No)	44.4 ±3.6	8.1 ±0.5	20.0 ±1.8	12.5 ±1.4
Shoot-dry-weight (gm)	8.7 ±0.9	1.0 ±0.1	10.1 ±1.3	2.5 ±0.3
Seed-Yield (gm)	2.0 ±0.23	0.2 ±0.05	6.0 ±0.70	0.7 ±0.12
100-seed-weight (gm)	5.0 ±0.34	3.7 ±0.39	9.2 ±0.37	7.3 ±1.35

The relatively 'bad' area in an alkaline field, in contrast with the 'good' area, is characterized by the presence of carbonates and a higher pH value, even beyond 8. Total soluble salts may or may not be high. The 'good' areas too, contain sufficiently high amount of total soluble salts and nearly resemble, in the chemical composition of their soils, the 'bad' areas of the saline fields.

All the growth characters under study, both in wheat and gram, are affected adversely. The percentage reduction in the two crops in height, shoot-dry-weight and seed-yield are included in Table VI.

Table VI

Influence of soil alkalinity on growth and yield of wheat and gram
(Percentage on respective controls)

Observation	Wheat			Gram		
	1953-54	1954-55	Average	1953-54	1954-55	Average
Height	48	40	44	55	54	55
Shoot-dry-weight	88	81	85	88	75	82
Grain or seed-yield	94	87	91	90	88	89

The reduction in yield and growth of the plants is considerable in both the crops, but the crop differences are not apparent.

(B) Effect of soil salinity and alkalinity on germination and seedling growth of wheat C. 591 and gram N.P. 28.

(a) Influence of soil salinity :

Table VII

Influence of soil salinity on germination and seedling growth of Wheat C. 591 and gram N.P. 28.

Observation	Wheat C. 591		Gram N.P. 28	
	'Good' area	'Bad' area	'Good' area	'Bad' area
Soil analysis (Mean of duplicate) :—				
Total soluble salts (mg/100 gm soil)	67	267	67	267
Chlorides (mg/100 gm soil)	15	40	15	40
Carbonates (mg/100 gm soil)	—	—	—	—
Bicarbonates (mg/100 gm soil)	36	72	36	72
pH	7.2	7.6	7.2	7.6

(*Contd.*)

Obserations	Weeat C. 591		Gram N.P. 28	
	'Good' area	'Bad' area	'Good' area	Bad' 'area
Germination % (Mean of duplicates) :	75	75	69	75
Growth at 4-week stage, (Mean of 10 values) :—				
Height (cm)	8.3	5.0	10.2	9.4
Leaves (No)	3.0	2.6	10.9	8.9
Branches (No)	1.0	1.0	2.6	1.8
Shoot-dry-weight (mg)	19	15	35	21
Growth at 8-week stage, (Mean of 10 values) :—				
Height (cm)	13.9	11.8	18.6	18.2
Leaves	3.9	3.8	19.0	18.0
Branches (No)	1.0	1.0	2.9	2.3
Shoot-dry-weight (mg)	55	51	55	34

The soil analysis for 'good' and 'bad' areas indicates that total soluble salts (chlorides and bicarbonates) are higher in 'bad' areas.

Germination was not influenced in either crop, although the rate of germination was retarded. The percentage of germination in two crops at the end of six days and at nine days are given below for the 'good' and bad' areas :

Soil	Wheat C. 591		Gram N. P. 28	
	Days after sowing			
	6	9	6	9
'Good'	63	75	50	69
'Bad'	44	75	25	75

Depressing influence of salinity on seedling top-growth was evident at 4-week stage ; height of plants, number of leaves and shoot-dry-weight was lowered in wheat ; in gram, even the number of branches was reduced. At the end of 8 weeks after sowing, trends for recovery were evident in wheat as well as in gram, more clearly in the former.

Comparing the two cro gram appear to suffer more than wheat, as indicated by the values o oot-dry-weight in 'bad' soil as percentage on good soil at 4 weeks and 8 v ks after sowing.

	Shoot- y-weight (% on 'good' soil)	
	Wheat .591	Gram N.P. 28
4-week stage	79	60
8-week stage	93	62

(b) Influence of soil alkalinity :

Table VIII

Influence of soil alkalinity on germination and seedling growth of wheat C. 591 and gram N. P. 28

Observation	Wheat C. 591		Gram N.P. 28	
	'Good' area	'Bad' area	'Good' area	'Bad' area
Soil analysis (Mean of duplicate) :—				
Total soluble salts (mg/100 gm soil)	150	110	150	110
Chlorides (mg/100 gm soil)	20	15	20	15
Carbonates (mg/100 gm soil)	—	8	—	8
Bicarbonates (mg/100 gm soil)	62	60	62	60
pH	7.3	8.1	7.3	8.1
Germination percentage (Mean of duplicate) :—	75	56	81	63
Growth at 4-week stage, (Mean of 10 values) :—				
Height (cm)	5.3	5.7	9.9	12.1
Leaves (No)	2.9	3.0	10.2	8.2
Branches (No)	1.0	1.0	2.3	1.7
Shoot-dry-weight (mg)	15	16	26	17
Growth at 8-week stage (Mean of 10 values) :—				
Height (cm)	11.8	7.0	19.1	19.1
Leaves (No)	3.4	2.8	20.4	17.5
Branches (No)	1.0	1.0	2.6	2.6
Shoot-dry-weight (mg)	47	45	48	37

The soil analysis from the alkaline fields reveals the presence of carbonates and higher pH in the 'bad' areas.

Germination was lowered in wheat and gram, and also the rate of germination was retarded. The values for percentage germination in 'good' and 'bad' soils at the end of 6 and 9 days are given below :

	Wheat C.591		Gram N.P. 28	
	Days after sowing			
Soil	6	9	6	9
'Good'	56	75	50	81
'Bad'	31	56	38	63

The effect of alkalinity on seedling-top-growth at 4 weeks after sowing was not apparent in wheat, but in gram lowering of shoot-dry-weight and number of leaves and branches was noticed. At 8-week stage, the depressing influence of the alkalinity became evident in wheat, height of plants and number of leaves was lowered ; in gram, a tendency for recovery from the depressing influence, shown at 4-week stage, was indicated.

Considering the influence of alkalinity on shoot-dry-weight alone at 4 and 8 weeks after sowing for 'bad' soil as percentage on 'good' soil are indicated below :

	Shoot-dry-weight (% on 'good' soil)	
	Wheat C. 591	Gram N.P. 28
4-week stage	107	65
8-week stage	96	77

DISCUSSION

Bower, et al (1954) have pointed out that electrical conductivity, exchangeable sodium, pH, etc. are the important soil characters which determine the crop growth in sugar-beets. The present investigation shows that the deleterious effect of saline and alkline soils on the growth and yield of wheat and gram is probably due to high concentration of total soluble salts, particularly chlorides and bicarbonates in saline soils and soluble carbonates and higher pH in alkaline soils.

Another noteworthy feature is that the 'good' area in the 'Alkaline' field does not resemble closely the 'good' area of a saline field ; in soil charactres analysed, it resembles approximately the 'bad' area of a saline field as indicated by the data presented in Table IX. It supports the observation of Russel

(1950) and Hayward and Wadleigh (1949) that distinction between saline and alkaline soils is entirely on the stage of deterioration of the soil ; the saline soil gradually became alkaline. Further, a comparison has been made between plant growth in 'good' and 'bad' areas of saline and alkaline fields ; the values are calcualted as percentages on 'good' area of the saline field, and are given in Table IX.

Table IX

Relation between soil analysis and plant growth
(Mean of two years data)

Observation	Wheat				Gram			
	Saline		Alkaline		Saline		Alkaline	
	'Good' area	'Bad' area	'Good' area	'Bad' area	'Good' area	'Bad' area	'Good' area	'Bad' area
Soil analysis :—								
Total soluble salts	66	205	208	139	142	297	142	164
Chlorides	8	20	22	23	19	23	25	38
Carbonates	—	—	—	11	—	—	—	16
Bicarbonates	29	66	55	39	51	70	55	63
pH	7.2	7.2	7.3	8.2	7.3	7·4	7.2	8.1
Plant growth :—								
Height	100	84	104	58	100	58	99	45
Shoot-dry weight	100	38	86	13	100	16	84	17
Seed-Yield	100	29	76	7	100	15	50	6

Note—Soil analysis for total soluble salts, chlorides, carbonates and bicarbonates has been expressed in milligrams per 100 gm of the soil.

From the above data, it is revealed that :

(*i*) Growth (shoot-dry-weight) and seed-yield of the plants in 'good' area of alkaline field when compared to the 'good' area of the saline field are lowered, but not to the level noted for the 'bad' area of the saline field, thus the assumption, which was made on the basis of soil analysis, that plants growing on the 'good' area of the alkaline field should show growth and maturity approximately similar to that of the plants in 'bad' area of the saline field is not, however, supported by the present data. But it may be noted that the chemical analysis relate only to the surface soil, and perhaps growth and maturity may be controlled by other factors also.

(*ii*) Gram appears to be more susceptible to soil salinity than wheat but the differences between the relative response of the two crops to soil alkalinity are not consistant.

However, the studies on seedling growth upto 8 weeks in pot culture offer a clear indication regarding the better performance of wheat than gram.

Finally, it is clear that growth and yield of both wheat and gram are directly affected by increase in concentration of total soluble salts, particularly the chlorides and bicarbonates, in saline soils, and by the presence of carbonates and higher pH in alkaline soils.

SUMMARY

Relatively 'good' and 'bad' areas from moderately saline and alkaline fields of cultivators, where wheat and gram crops were growing, were selected. 20 'random' plants, of each wheat and gram, were harvested at maturity from these areas and observation on growth and yield were noted. Soil samples from 0—6″ layer were collected from the same areas and total soluble salts, chlorides, carbonates, bicarbonates and pH were estimated. An attempt has been made to correlate the soil factors with the plant growth.

Further, germination and seedling growth (upto 8-week stage) of wheat and gram were studied in pots filled with soil (0—6″ layer) from the 'good' and 'bad' areas; the pots were watered frequently to maintain favourable water supply to the plants and the leachates were returned to the soil ; the object of this experiment was to study the germination and early growth of wheat and gram plants in soil from the 'good' and 'bad' areas under controlled conditions, chiefly of favourable water-supply.

The conclusions based on these studies are :.

(*i*) Shoot-dry-weight at maturity and grain or seed-yield of both wheat and gram seems to be related to the total soluble salts and pH of the soil (0—6″ layer).

(*ii*) In the saline fields, the yield of straw and grain or seed of wheat and gram are adversely influenced by increase in total soluble salts, particularly bicarbonates and chlorides.

(*iii*) The adverse effect of soil salinity is more pronounced in gram than in wheat.

(*iv*) Growth and yield of both the crops are depressed considerably by increase in pH and in the amount of soluble carbonates (*i.e.*, alkaline condition) of the soil ; the crop differences are not clear.

(*v*) The studies on germination and seedling growth upto 8-week stage in pot cultures indicates that :

(a) In saline soils germination of both wheat and gram is not influenced; the depressing influence on growth was evident at 4-weeks after sowing followed by a tendency to recover ; gram suffered more than wheat.

(b) In alkaline soils both germination and growth of the plants is depressed ; in wheat the depressing influence became apparent only at 8 weeks after sowing while in gram it was clear at 4-week stage, however, trends for recovery were indicated later on ; gram suffered more than wheat.

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THE CHLOROPHYCEAE OF THE KUMAON HILLS, U.P., INDIA—I

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Rao,[1] Singh[2],[3] and Singh[4] have recorded in a series of papers the chlorophyceous flora of several districts in the plains of Uttar Pradesh, but no member of this class has yet been recorded from the hilly districts of Kumaon region. It is, therefore, desired to record these algae in a series of papers, and the present communication deals with some of the Chlorophyceae of Nani Tal district only. In all there are thirty-eight forms, representing twenty-four genera.

SYSTEMATIC ENUMERATION OF THE SPECIES OBSERVED

1. *Chlorogonium elongatum* (Dangeard) Franze. Pascher, "Volvocales-Phytomonadineae". In ; Die Süsswasserflora Deutschlands, Österreich und der Schweiz, *Heft 4*, Chl. 1, p. 316, Figs. 283-84, 1927.

Lat. cell., 4.5-5μ ; long. cell., 39.5-43.5μ.

Habitat.—In a pool along with an *Euglena* species, Naini Tal. (May, 1956).

2. *Carteria globosa* Korshikov. Pascher, *op. cit.*, Heft 4, Chl. 1, pp. 143-44, Fig. 89A, 1927.

Cells 16.8-21. 2μ in diameter.

Habitat.——In a water reservoir, Dhobi Ghat, Naini Tal. (June, 1958).

3. *Hormidium rivulare* (Kütz.) Heering. Heering, "*Ulotrichales, Microsporales, Oedogoniales*". In : Pascher, Die Süsswasserflora Deutschlands, Oesterreichs und der Schweiz, *Heft* 6, Chl. 3, p. 47, Fig. 56, 1914.

Lat. cell. 5—10μ ; long. cell., 8.5—14.5μ.

Habitat.—In a stream on Ratighat Road, Nani Tal. (August, 1958).

4. *Hormidium subtile* (Kütz.) Heering. Pascher, *op.cit.*, *Heft*, 6, Chl. 3, p. 48, 1914.

Lat cell., 5-6μ ; long. cell., 2.5-10.5μ.

Habitat.—On moist rock, Beer Bhatti, Naini Tal. (September, 1957).

5. *Fritschiella tuberosa* Iyengar. Iyengar, "*Fritschiella*, a new member of the Chaetophoraceae". *New Phytol.*, *Vol. xxxi*, No. 5, pp. 329-35, Figs 1-2, 1932.

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[3] Singh. R. N., "The Oedogoniales of U. P., India—I". *Proc. Ind. Acad. Sci.* Sec, B, *Vol. 8.* no. 5, pp. 373—95, 1938.

[4] Singh. V. P., "The Chlorophyceae of the Banaras District, U. P., India- I". *Proc. Ind. Acad. Sci.*, Sec. B, *Vol. 14*, no. 3, pp. 256—60, 1941.

Lat. cell. of projecting system., 4.5-8-5μ ; long cell of projecting system, 9.5-25.5μ ; Crass. cell of prostrate system., 8.5-19.5μ.

Habitat. —From abondoned tennis lawn in Pyagpur Khoti, Naini Tal., (November, 1958).

6. *Protococcus viridis* Ag. Brunnthaler, "*Protococcales.*" In : Pascher, Die Susswasserflora Deutschlands, Osterreichs und der Schweiz, *Heft* 5, Chl. 2, p. 224, 1915.

Diam. cell., 8—20μ.

Habitat.—On moist rock, tree trunks and on surface of flower-pots, Naini Tal. (July, 1956-58).

7. *Trentepohlia aurea* (Linn.) Martius Pascher, *op. cit.*, *Heft.* 6, Chl. 3, p. 122, 1914.

Lat. cell., 10.30μ ; long., cell., 25-45.5μ.

Habitat.—On moist rocks and tree trunks , Naini Tal. (October, 1957).

8. *Monostroma quaternarium* (Kütz.) Desm. Pascher, *op. cit.*, *Heft.* 6, Chl. 3, p. 21, 1914.

Diam. cell., 11.9-17.5μ.

Habitat.—In a swift running stream on Ratighat Road, Naini Tal. (September, 1957-58).

9. *Oedogonium lageniforme* Hern. Tiffany, "*The Oedogoniaceae*", p. 168, Pl. XX, Fig. 187, 1930.

Lat. veg. cell., 11.7-15.6μ ; long. veg. cell., 39.0-82.4μ; lat. oog., 35.1-42.9μ ; long . oog., 42.9-63μ ; lat. oopsore., 31.5μ.

Habitat.—From a tank, Bhowali, Naini Tal. (September, 1958).

10. *Oedocladium operculatum* Tiffany. Tiffany, "Wille's Collection of Puerto Rican Fresh-water Algae". *Brittonia*, *Vol.* 2, No. 2, pp. 165-176, 1936.

Lat. veg. cell., 13.5-15.6μ ; long. veg. cell., 46.8-78.0μ ; lat. oog., 35.1-39.0μ ; long. oog., 46.8-50.7μ ; lat. oospore., 35.1-36.5μ ; long. oospore., 39.0μ ; lat. anth., 11.7μ ; long. anth., 7.2-27.3μ.

Habitat.—On moist soil, Naini Tal. (November, 1957).

11. *Cladophora glomerata* (Linn.) Kütz. Pascher, *op. cit.*, *Heft* 7, Chl. 4, p. 35, 1921.

Lat. cell., 30-80μ or more ; long. cell., 100-300μ.

Habitat.—In a running stream neer Evelyn Hotel, Naini Tal. (October, 1958).

12. *Rhizoclonium hieroglyphicum* Kütz. Pascher, *op. cit.*, *Heft* 7, Chl. 4, p. 20, 1927.

Lat. veg. cell., 35.1-50.7μ

Habitat.—In a waste water drain along with *Oscillatoria acuminata*, Naini Tal. (September, 1957).

13. *Characium angustum* A. Br. Pascher, *op. cit*, *Heft* 5, chl. 2, p. 79, 1915.

Lat. cell., 3.4-6.8µ ; long. cell., 13.6-37.4µ.

Habitat.—Epiphytic on *Hydrodictyon reticulatum*, Sukha Tal, Naini Tal. (August, 1958).

14. *Protosiphon botryoides* (Kütz.) Klebs. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 86, 1915.

Lat. vesicle., 55-85µ ; long. vesicle., 50—100µ ; lat. rhizoid., 13-42µ ; long rhizoid., 60-200µ.

Habitat.—On moist soil, Naini Tal. (November, 1958).

15. *Pediastrum tetras* (Ehrbg.) Ralfs. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 103, 1915.

crass. colony., 65µ ; lat. marginal cell., 7.5-9µ ; long. marginal cell., 10.5 - 12µ ; crass. central cell., 7.5-8.5µ.

Habitat.—From a water reservoir in Government House campus, Naini Tal. (August, 1958).

16. *Hydrodictyon reticulatum* (L.) Lagerh. Pascher, *op. cit.*, *Heft* 5, chl. 2 p. 107, 1915.

Lat. cell., up to 0.4 mm ; long cell., up to 2 mm.

Habitat .—From Sukha Tal along with *Characium angustum*. (August, 1958).

17. *Chlorella vulgaris* Beyer. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 111, 1915.

crass. cell., 5—8.5µ.

Habitat.—On moist soil, Naini Tal. (August, 1958).

18. *Oocystis elliptica* G.S. West. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 126, 1915.

Lat. cell., 11-11. 51µ ; long. cell., 24-25µ.

Habitat.—From a dripping rock, Naini Tal. (October , 1948).

19. *Oocystis Naegelii* A. Br. pascher, *op. cit.*, *Heft* 5, chl. 2, p. 127, 1915.

Lat. cell., 4.2-6.8µ ; long. cell., 8.5-11.9µ.

Habitat.—From a swimming pool of Government House along with *Scenedesmus dimorphus*, *Cosmarium nitidulum* and *Scenedesmus quadricauda*, Naini Tal. (October, 1958).

20. *Oocystis rupestris* Kirch. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 129, 1915.

Lat. cell., 6.8-7.8µ ; long. cell., 11.7-20.5µ.

Habitat.—From a water reservoir in Balrampur House, Naini Tal. (August, 1958).

21. *Scenedesmus dimorphus* (Turp.) Kütz. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 166, 1915.

Lat. cell., 2.5-5.1µ; long. cell., 18-23µ.

Habitat.—From a swimming pool in Government House, Naini Tal, along with *Oocystis parva*, *Scenedesmus quadricauda* and *Cosmarium nitidulum*. (October, 1958).

22. *Scenedesmus quadricauda* (Turp.) Breb. Pascher, *op. cit.*, *Heft* 5, chl. 2, p. 165, 1915.

Lat. cell., 2.5-3.4μ ; long. cell., 8.5 - 15μ.

Habitat.—From a swimming pool of Government House, Naini Tal, along with *Scenedesmus dimorphus*, *Oocystis parva* and *Cosmarium nitidulum*. (October, 1958).

23. *Vaucheria sessilis* (Vauch.) D.C. Heering, "*Siphonocladiales, Siphonales*". In : Pascher, Die Susswasserflora Deutschlands, Oesterreichs und der Schweiz, Heft 7, chl. 4, p. 87, 1921.

Lat. fil., 60 - 110μ ; lat. oog., 60 - 80μ ; long. oog., 80-98μ ; lat. oosp., 60 - 80μ ; long. oosp., 49.5-66.5μ.

Habitat.—On moist soil, Ratighat, Naini Tal. (August, 1958).

24. *Vaucheria clavata* D.C. *Journ. Asiat. Soc. Beng.*, Vol. XL (2), p. 461 1872.

Lat. fil., 46.8-85.5μ ; lat. oog., 85.8-97.5μ ; long. oog., 70.2-78.0μ ; lat. oosp., 70.2 - 74.1μ ; long. oosp 49.5 - 66.3μ.

Habitat.—Subaerial near Jwala Cottage, Sleepy Hollow, Naini Tal. (October, 1958).

25. *Vaucheria borealis* Hirn. Pascher, *op. cit.*, *Heft*.7, chl. 4, p. 84, 1921.

Lat. fil. 54.6-81.9 μ ; lat. oog., 120-145μ ; long. oog., 81.9- 105μ; lat. oosp., 58.6 - 66.4μ; long. oosp., 54.6-62.4μ.

Habitat.—Subaerial near Bisht Bhawan, Naini Tal. (September, 1958).

26. *Zygnema terrestre* Randhawa. Transeau, "*The Zygnemataceae*", p. 28, Pl. VII, Fig. 16-18, 1951.

Lat. veg. cell., 20-24μ; long. veg. cell., 35-65μ ; lat. zygosp., 25-38μ ; long. zygosp., 35. 50μ ; lat. aplanosp., 30.5-36μ ; long. aplanosp., 36.5-63.2μ .

Habitat.—On moist soil, Naini Tal. (October, 1957).

27. *Zygnema gedeanum* Czurda. Transeau, *op. cit.*, p. 27, pl. III, Figs. 11-12, 1951.

Lat. veg., 13.5-16μ ; long. veg., cell., 28.5-40μ ; lat. zygosp., 22.6-25.5μ ; long. zygosp., 28.5-35μ.

Habitat.—In a water reservoir near secreteriate building, Naini Tal. (November, 1958).

28. *Zygnema adpectinatum* Transeau. Transeau, *op. cit.*, p. 25, pl. III, Fig. 4, 1951.

Lat. veg cell., 20.7-23.4μ ; long. veg. cell., 30.5-97.8μ ; lat. zygosp., 31.2-35.5μ ; long. zygosp., 40-46.8μ.

Habitat.—On moist soil near Pines, Naini Tal. (October, 1958).

29. *Spirogyra Jüergensii* Kütz. Transeau, *op. cit.*, p. 151, Pl. I, Fig. 1, 1951.

Lat. veg. cell., 28-31.2µ ; long. veg. cell., 80-160µ ; lat. zygosp., 36-40µ ; long. zygosp., 40-64µ.

Habitat.—Subaerial near Ramsay Hospital, Naini Tal. (September, 1958).

30. *Spirogyra longata* (Vauch.) Kütz. Transeau, *op. cit.*, p. 158, Pl. XXIII, Fig. 5, 1951.

Lat. veg. cell., 31.2 - 35.2µ ; long. veg. cell., 66.3-240µ ; lat. zygosp., 28-42.9µ ; long. zygosp., 66.3-81.9µ.

Habitat.—subaerial near Rohilla Cottage, Naini Tal. (October, 1958).

31. *Sirogonium megasporum* (Jao) Transeau. Transeau, *op. cit.*, p. 233, Pl. XL, Fig. 5, 1951.

Lat. veg. cell., 39.0-50.7µ ; long. veg. cell., 89.5 - 356.5µ ; lat. zygosp., 74.1-85.8µ ; long. zygosp. 89.7-120.9µ.

Habitat.—Subaerial along with *Aulosira laxa* var. *microspora*, Naini Tal. (November, 1958).

32. *Sirocladium kumaoense* Randhawa. Randhawa, "*Sirocladium*, a new terrestrial member of Zygnemales". *Bot. Gaz.*, *Vol.* 103 (1), pp. 192-97, 1941.

Lat. veg. cell., 45-64µ ; long. veg. cell., 120 - 210µ ; lat. chromatophore., 15-20µ ; lat. zygosp., 42-47µ ; long. zygosp., 90-108µ.

Habitat.—On moist soil, Naini Tal. (July-November, 1956-58).

33. *Cosmarium subcucumis* Schmidle. Croasdale, "Fresh-water Algae of Alaska". *Trans. Amer. Micros. Soc.*, *Vol. XXXV*, No. 1, p. 53, pl. IV, Fig. 1, 1956.

Lat. cell., 34-35.77µ ; long. cell., 47.6-56µ; isth., 13.6-18µ.

Habitat.—From a dripping rock, NainiTal. (October, 1958).

34. *Cosmarium Hammeri* Reinsch. Croasdale, *loc.cit* p. 36. Pl. VI, Fig. 7, 1956.

Lat. cell., 36-50µ ; long. cell., 48-56µ; isth., 8-12µ.

Habitat.—From a moist rock near Ramsay Hospital, Naini Tal . (October, 1958).

35. *Cosmarium nitidulum* De-Not, De-Toni, *Syllg. Alg. CHL.*, p. 935, 1889.

Lat. cell., 19.5-23.5µ ; long. cell., 27.3-43µ ; isth., 13.6-15.6µ.

Habitat.—From a swimming pool of Government House, Naini Tal, along with *Scenedesmus dimorphus*, *Oocystis parva* and *Scenedesmus quadricauda*. (October, 1958).

36. *Cosmarium granatum* Breb. De-Toni, *op. cit.*, p. 937, 1889. Lat. cell., 15.6 - 16.2µ ; long. cell., 19.5 - 31.2µ ; isth., 7.8µ.

Habitat.—From a moist rock, Naini Tal. (August, 1958).

37. *Cosmarium Pankakoskii* Gronblad. Gronblad, "Desmidiceen aus Salmi". *Acta. Soc. Fauna Flora Fennica,* 66, p. 24, 1947.

Lat. cell., 32-34.5μ ; long. cell., 31-35.1μ ; isth., 10-12μ.

Habitat.—From a dripping rock, Ratighat, Naini Tal. (September, 1958).

38. *Cosmarium franztonii* var. *subarcticum* Croasdale. Croasdale, *loc. cit,* 1956, *Vol. LXXV,* No.1, p. 32, Pl. XIII, Fig. 9.

Lat. cell., 45-59.5μ ; long. cell., 54-75.5μ ; isth., 15.6 - 19.3μ.

Habitat.—From a dripping rock, Naini Tal. (September, 1958).

MORPHOLOGICAL STUDIES IN SOME MEMBERS OF THE FAMILY PEDALIACEAE*

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The present morphological investigation deals with four plants of Pedaliaceae (B.H.)[1] namely, *Sesamum indicum* L. ; *Pedalium murex* L.; *Martynia diandra* Glox.; and *Trapella sinensis* Oliv.

Flowers of *Sesamum*, *Pedalium* and *Trapella* are mostly solitary and axillary, while in *Martynia* they are produced in racemose inflorescence, and each flower has two bracteoles. In *Sesamum* and *Pedalium* the pedicel of the flower in its lower region bears two laterally placed button-shaped neclaries in the axil of bracts. It has been shown that the nectaries are modified flower buds for secretion, and thus it is concluded that the flower and its associated nectaries compose a reduced trichome.

The floral parts are differentiated in acropetal succession. Calyx, corolla and androecium are initiated as five alternating whorls of outgrowths, while the gynaecium is initiated as two semi-circular outgrowths. The placentae are organized at the junctions of these semi-circular carpel initials. The placentae grow inwards and divide the ovary cavity in *Sesamum* and *Pedalium*, while in *Martynia* they remain free and laterally extended. In *Sesamum* the development of additional false septa further divide the ovary which ultimately becomes four-chambered. In *Pedalium*, however, no such change takes place, and hence the overy remains bilocular.

The vascular system in the pedicel of all the four plants forms a complete vascular ring. In the region of the receptacle, ten traces are given out to supply the peripheral whorls of the flower. Five of these alternating ones are the common traces for the corolla and the calyx laterals, while the other five are common traces for the calyx median and the staminal traces. In *Trapella* the five alternating ones are the common traces for calyx median and the staminal bundles, while the other five are common traces for the corolla and the spines. The spinal traces have been shown to be the fused calyx laterals of the adjoining calyx. In *Pedalium* and *Martynia* five alternating bundles, out of the original ten traces, form the common traces for the calyx laterals and the corolline traces, while the other five serve as the calyx medians. In these plants the supplies to the stamens are given out from the main stele at the points just above the gaps formed by the calyx medians.

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[1] Bentham & Hooker (1862-83).

After the traces for the peripheral whorls have separated, the vascular tissue of the central stele organizes to form the vascular supply of the gynaecium. In *Sesamum* there are two dorsal and four normally oriented ventral carpellary bundles. From the latter placental traces are given out, which are also normally oriented, and they give out ovular traces during their ascent into the placental column. *Pedalium* has a more or less similar vascular supply, except that there are only two ventral bundles formed by the fusion of the ventral bundles of the two adjoining carpels. The placental bundles given out from these ventral carpellary bundles give out ovular traces to the four ovules attached near the upper portion of the placentae. In *Trapella* there are two placental bundles (probably the fused ventral carpellary bundles) which directly supply the two ovules. The dorsal carpellary bundles are very poorly developed and could be seen only in the upper portion of the ovary. In *Martynia* there are two dorsal carpellary and four inversely oriented ventral carpellary bundles. The latter ascend the T-shaped parietal placentae and give out four ovular traces in the region of the ovular attachment.

The study on the floral anatomy has revealed that the ancestral type of gynaecium for these plants has superior ovary with parietal placentae bearing ovules on the margins of the two carpels. During evolution the placentae intruded and divided the ovary cavity as in *Sesamum*, *Pedalium* and *Trapella*, while in *Martynia* they remained free and laterally extended. Thus intrusion of the placentae is accompanied by the reduction in the number of the ovules so that in *Trapella*, there are only two ovules of which only one develops finally to maturity.

The inferior ovary of *Trapella* has been shown to be of dual nature. The portion lower to the spines is formed by the excessive zonal growth in the cortex, while the portion in the vicinity of the spines by the fusion of the floral appendages.

The another wall in *Sesamum*, *Pedalium* and *Martynia* is four to five layers thick and is differentiated into epidermis, endothecium, one or two middle layers, and a layer of tapetum. The tapetum of the connective side develops from the cells underlying the sporogenous cells. The tapetum is of glandular type and during degeneration of tapetal cells refractive droplets appear on the inner walls. The mature pollen grains are trinucleate in *Sesamum*, *Pedalium* and *Trapella*, and only binucleate in *Martynia*. In *Sesamum* and *Pedalium* the exine is thick with ten and six longitudinal furrows (Colpi)[1] respectively. The furrows run between the poles. In *Martynia* the exine thick and there are 15 small furrows (rugae)[1] arranged in pentagonal pattern, while *Trapella* has thin exine and only three furrows, (Colpi)[1].

The archisporium functions directly as the megaspore mother cells, and the embryo sac development is of Polygonum type. The mature embryo sac contains an egg apparatus, two polars or a secondary nucleus and, with the exception of *Trapella* ephemeral antipodals. In *Trapella* they are seen up to the time of fertilization.

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[1] Terminology after Erdtman (1952)

The endosperm development is of cellular type. The division of the primary endosperm nucleus always results in a transverse division of the embryo sac into two segments. The micropylar segment forms the endosperm proper and the micropylar haustorium, while the chalazal segment forms the chalazal haustorium only. In *Trapella* the micropylar and the chalazal haustoria are differentiated more or less simultaneously and consist of four and two cells, respectively ; while in other three plants the micropylar haustorium is many celled and is differentiated slightly later. The structure of the chalazal haustorium is slightly different in *Sesamum, Martynia* and *Pedalium.* In *Sesamum* it consists of four uninucleate cells, and in *Martynia* also it consists of four cells, later on each of them, however, becomes multinucleate. In *Pedalium* the chalazal haustorium is a four-nucleate coenocytic structure.

Embryo development is of Onagrad type, only showing Catalpa variation in *Martynia.* The mature embryo is spathulate[1] in *Sesamum, Pedalium* and *Trapella,* while in *Martynia* it is of partially investing type.[1] In *Martynia* the cotyledons have two-layered palisade cells while in others there is only a single layer of palisade cells.

The ovules are anatropus, pendulous, unitegmic and, with the exception of *Trapella,* have dorsal raphe. In *Trapella,* the raphe is ventral. The seeds contain a thin layer of endosperm and the whole inner space is occupied by the large sized embryo. In *Trapella,* however, the persisting micropylar haustorium forms a very characteristic structure at the micropylar end of the seed. The chief layer of the seed coat is the outer epidermis of the integument. In *Sesamum, Pedalium* and *Martynia* the seed coat consists of thick walled outer epidermis, a few layers of crushed parenchyma and the inner cuticle, while in *Trapella* it is exclusively formed of thin walled outer epidermis of the integument.

The fruit is dehiscent, non-spinous and many-seeded in *Sesamum,* partially dehiscent, spinous and few seeded in *Martynia*; and indehiscent, spinous and few-seeded in *Pedalium* and *Trapella.* The ovary wall is differentiated into two portions, the outer of parenchymatous cells and the inner of fibrous tissue. In *Martynia* the outer parenchymatous layer falls off during the ripening of the fruit. Dehiscent and indehiscent nature of the fruit has been found to be closely associated with the nature and the type of arrangement of the fibre cells. The morphological nature of the spines has been found to vary. In *Pedalium* and *Martynia* they are formed by the strong fibrous development in the positions of the lateral bundles of the carpels and hence are of carpellary tissue while in *Trapella* they are formed by the fibrous development in association with the calyx laterals and are thus of an appendicular tissue.

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[1] Terminology after Martin (1949).

Finally it has been shown that the plants have an affinity with Scrophulariaceae, particularly on the basis of endosperm character. The separation of *Martynia* to a separate family, Martyniaceae, is fully supported on the basis of floral anatomy, embryology, seed and fruit structure. Similarly, the separation of *Trapella* to a new family, Trapellaceae, as suggested by Erdtman (1954), is also supported. Furthermore, the four plants represent three more or less divergent lines of development from some common ancestor. *Sesamum* and *Pedalium* represent the main line of the family Pedaliaceae and show a similarity with Scrophulariaceae and Bignonieceae, while *Martynia* representing another line is more akin to Bignoniaceae. *Trapella* constituting the third line of development, however, shows closeness with Scrophulariaceae and Pedaliaceae with the exception of the inferior condition of its ovary.

ROLE OF POTASSIUM DEFICIENCY IN SURGICAL PATIENTS; ITS RECOGNITION AND MANAGEMENT*

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INTRODUCTION

Development of new physical and physiochemical procedures and lately the introduction of flame photometer has made possible the study of electrolytes like Potassium and sodium and their significance. Experimental work went on for several years before clinicians like Darrow and Gamble realised the significance of potassium in states of electrolyte disturbances seen in infantile diarrhoea.

It is only of late that surgeons have started appreciating the importance of this chief intracellular action. The importance of potassium loss and its assessment cannot be over exaggerated in certain surgical patients in whom the chances of their life may be crucially determined by changes brought about by a little alteration in their serum potassium level.

The emergence of the concept of stress in disease, introduced lately by Hans Salye, has further sought to correlate the phases of biological fluxes in the bio-chemical composition of the body during various phases of stress. Since every minor of major surgical procedure is attended by syndrome of stress, it is but matural to anticipate these changes occuring concurrently and subsequently by episodes.

MATERIAL AND METHOD

In the present study 50 surgical cases were studied while being admitted to surgical wards of S. N. Hospital, Agra. After the record of brief clinical history repeated examinations of potassium, sodium and chloride in blood were done in every case.

The examination as a routine were undertaken at the time of admission, on the morning of operation and subsequently at frequent intervals fill the serum potassium values returned to normal.

The estimation of sodium and potassium were done by Eel's flame photometer, while chroides were estimated by chemical fitrimetric method.

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Table I

No.	Operation done	Pre-operative serum K.m. Eq./L.	Lowest post-operative serum K· m. Ed./L.	Day of lowest serum K.
1.	Partial Gastrectomy.	4.1	2·9	4th
	,, ,,	4.8	3·1	4th
2.	Pyloric stenosis (Gastrojejunostomy)	4.4	3.1	6th
	,, ,,	4.2	3.3	5th
3.	Hemicolectomy	4.5	3.3	6th
4..	Acute intestinal obstruction.	6.0	2.0	3rd
5.	Cholecystectomy	4.9	3.3	6th
6.	,, ,,	4.5	3.2	9th
7.	Ilio-colostomy	4.6	3.5	7th
8.	,, ,,	4.5	3.3	7th
9.	Colostomy	5.0	4.7	4th
10.	Acute appendicitis (Appendicectomy)	4.6	4.4	5th
11.	,, ,,	5.1	4.9	6th
12.	,, ,,	4.6	4.1	6th
13.	Chronic appendicitis (Appendicectomy)	5.7	5.1	6th
14.		4.7	4.6	5th
15.		4.5	4.4	4th
16.	Pyelolithotomy	4.5	2.5	6th
17.	Prostatectomy	2.8-4.2	3.1	3rd
18.	Faecal Fistula	4.5	2.5	6th
19.	(resection and anastomosis)	4.6	3.4	6th
20.	Removal of ovarian cyst	4.8	2.5	6th
21.	Laparatomy	4.4	3.8	4th
22.	,,	5.4	4.7	3rd
23.	,,	4.4	3.7	4th
24.	,,	4.4	4.5	3rd
25.	,,	4.5	4.5	2nd
26..	,,	4.6	4.5	4th
27..	,,	4.5	4.3	3rd
28.	,,	5.3	3.4	7th
29.	Strangulated Hernia	5.4	5.0	4th
30.	,,	4.2	4.0	3rd
31..	,,	5.5	4.8	2nd
32.	ernioplasty	4.3	4.5	3rd
33.	,,	5.2	4.5	6th
34.	,,	4.6	4.6	2nd
35.	,,	5.7	5.2	3rd
36.	,,	4.6	4.6	4th
37.	,,	4.6	4.6	4th
38..	,,	4.6	4.6	3rd
39.	,,	4·6	4.6	2nd
40.	,,	4.9	4.8	2nd
41.	Thoracoplasty	4.7	4.0	7th
42..	Leminectomy	4.8	4.6	4th
43.	Lumbar Sympathectomy	4.6	4.1	6th
44.	Sub total thyroidectomy	4.9	3.1	8th
45..	Ostectomy	4.5	4.5	7th
46..	Liver abscess	4.5	4.6	4th

OBSERVATIONS

The serum potassium level in these cases was mostly between 4.3 m. Eq./L to 5.3 m. Eq./L (e. g. in 36 cases while 6 cases had their serum potassium level above 5.3 m. Eq./L and 3 cases below 4.3 m. Eq./L. Only one case of (enlarged prostate) had a pre-operative potassium deficit with serum potassium of 2.8 m. Eq/L. This level returned to normal within 5 days on normal diet which was supplemented by fruid juices and Pot. Citras, Acetas and bicarb gr. XV each, before operation. The following chart shows the serum potassium level pre-operatively and the response to different operative procedures in the post-operative period and also the day which recorded the lowest serum potassium level.

Most of these cases were on normal diet intake till just one night before the day of operation and accordingly none of them had any obvious reason for any potassium or any other electrolyte imbalance. In one case, however, the serum potassium concentration on the day of his admission (when he was in a state of marked dehydration, malnutrition and starvation) was 2.8 m. Eq./L. but this rose to 4.1 m. Eq./L. before the time of operation. This return to normal was recorded with just normal hospital diet supplemented with fruits and no other treatment was felt necessary because the patient could take his food orally. Two cases who came with signs of acute intestinal obstruction (Table No. II) had nothing from mouth. They had a history of vomiting and evidence of dehydration. Both of them were rehydrated before operation but none of them showed abnormally low serum potassium or any other clinical sign of potassium deficiency at admission.

It was not possible to work out a potassium balance, but urinary excretion of potassium was measured in some cases. It was observed that urinary excretion in all cases continued after operation in the same or sometimes in excess even though there was no intake of potassium during that period. In most of the cases though the total amount of urine output was decreased but the fall in the amount of potassium excretion was not proportional to it. Majority of the cases had no potassium intake by any route for about 24 hours while in some cases it was restricted from 1 to 4 days. The latter group of cases were the ones whose gastro-intestinal suction drainage and I.V. fluid therapy was continued for a variable period after operation on G.I. tract *e. g.* partial gastrectomy and hemicolectomy (Table No. II). In some of the cases though the total potassium excretion was decreased but still it continued in sufficient amount inspite of the absence of potassium intake and potassium loss through G.I. suction.

Table II

No	Pre-operative K. M.Eq./L	Lowest Post-op. serum K. M.Eq./L	Gestric aspiration	I. V. fluids	Signs and Symptoms				Return to normal
					Cong. of lungs	Abd. dist.	Weakness of limbs	Tendo reflex	
Partial gastrectomy									
1.	4.2	2.9	3 days	3 days	...	...	...		8th days
2.	4.8	3.1	3 days	3 days	...	...	...		9th days
Pyloric stenosis (Castro jejunostomy done)									
3.	4.2	3.1	3 days	3 days	...	...	...	Normal	6th
4.	4.4	3.3	4 days	5 days	...	...	...	Normal	10th
Faecal fistula									
5.	4.5	2.5	...	...	...	...	...	Diminished	9th
6.	4.5	3.4	...	...	...	...	...	,,	10th
Cholecystectomy									
7.	4.9	3.3	5 days	5 days	...	...	...	Normal	9th
8.	4.5	3.3	3 days	5 days	...	...	...	Normal	9th
Hemicolectomy									
9.	4.5	3.3	5 days	5 days	...	...	...	Normal	10th
Colostomy									
10.	5.0	4.7	2 days	2 days	...	...	...	Normal	6th
Iliocolostomy									
11.	4.6	3.5	2 days	2 days	...	...	...	Normal	9th
12.	4.5	3.3	5 days	5 days	...	...	...	Normal	10th
Appendicectomy									
No. of cases 6	4.3 to 5.7	4.1 to 5.1	One day in some cases	One day in some cases	...	...	...	...	3rd to 4th
Acute intestinal obstruction									
13.	4.2	1.7	Throughout	all 4 days	...	...	...	Absent	died on 4th days
14.	6.0	2.0	Throughout	all 3 days	...	...	...	Absent	died on 3rd days

Table II (*Contd.*)

No	Pre-operative K. M. Eq./L	Lowest Post-op. serum K. M.Eq./L	Gestric aspiration	I. V.	Signs and Symptoms				Return to normal
					Cong. of lungs	Abd. dist.	Weakness of limbs		
								Tendo reflex	
Strangulated hernia									
9 cases of simple hernia									
	4.3 to 5.7	4.3 to 5.1	...	...	...	...	...	...	1-3 days
3 cases of strangulated hernia.									
	4.1 to 5.3	3.8 to 4.8	1 day in some cases	1 day in cases	*in one case	+in one case		...	3-4th days.

I. V. FLUID AND POTASSIUM RESPONSE

Cases kept on I.V. fluid for a long time showed a constant fall of serum potassium level. This fall was more marked in cases where I. V. fluid theraphy, containing no potassium in it, had been started preoperatively and was also more marked when associated with gastrointestinal suction drainage. Administration of 5 per cent glucose or 10 per cent dextrose increased the total excretion of potassium in urine. This was associated with diuresis caused by 5% glucose.

HPOCHLOREMIA

Severe hypochloremia was observed in 2 cases only both the cases had pyloric stenosis and did not respond satisfactorily to I.V. fluid therapy with saline and 5% glucose. Though the patients were rehydrated, they were still drowsy, listless and apethetic and felt quite weak. They recovered when normal diet intake was started orally and when potassium salt was given orally in one case.

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*Immediately after operation a small rise in serum potassium was noticed in some cases. This was followed by a varying degree of fall in the serum potassium level. The latter was observed in most of the cases but its extent was proportional to the severity of the operation. Herniorraphy and appendectomy showed a comparatively small fall. (Table No. I and II as compared to those after partial gastrectomy, hemicolectomy and thoracoplasty) (Table No. II). Even out of these, greater fall in serum potassium was observed in cases undergoing surgery in their G.I. Tract (Table No. II) as compared to others.

Mild degree of hypochloremia was observed in a number of cases but they required no special treatment and blood picture returned to normal as soon as oral intake of food was started.

MUSCULAR WEAKNESS

Patients who manifested potassium deficiency felt week but rarely complained until asked for. The weakness was proportional to the severity of the operative trauma as shown in table No. III and IV.

Table III

Total No. of cases.	Normal post-op. serum K	Post-op. hypokalemia	Cases without weakness	Cases with weakness	weakness without K-Def.	Weakness with K-Def.	paraplegia
50	34	16 (32%)	30 (58%)	20 (40%)	8 23·5% of casses without hypoakalemia	12 75% of cases hypokalemia	2

Table IV

No. of cases showing weakness with hypokalemia	Severe muscular weakness with absence of knees jerk.	Severe muscular weakness with knee jerk present.	Moderate weekness	Slight Weakness
12	2	2	5	3

CONGESTION OF LUNGS

Out of 34 negative cases (cases without hypokalemia only 4 cases developed congestion of lungs while out of 16-positive cases (with hypokalemia) 9 cases (60%) developed congestion of lungs. Congestion of lungs was observed associated with shallow respiration caused by weakness of respiratory muscles

ABDOMINAL DISTENSION AND INTESTINAL ILEUS

With increasing intensity severity of hypokalemia, abdominal distension was quite a constant feature. Abdominal distension was observed in 23 out of 50 cases. Only 10 out of 34 negative cases showed abdominal distension *i. e.* 29.4% while out of 16 positive cases, 13 cases (81.2 percent) develope distension of abdome.

Abdomen was silent in 5 cases and varying degree of abdominal ileus was observed. All these cases had quite low serum potassium level. 2 cases of intestinal obstruction who had post-operative serum potassium level of 1.7 and 2.0 m. Eq./L had complete intestinal ileus. Both the cases expired on 3rd and 4th days.

DISCUSSION

Many of the conditions which are known to lead to potassium deficiency states can, and often do, exist in surgical patients. Losses as a result of reduction or elimination of potassium intake through G. I. T. are almost the rule. If one adds the effect of infusion with increased excretion of potassium and its possible withdrawal in glycogenesis, as well as the effect of saline infusion in increasing potassium loses, almost every post operative surgical case becomes a potential candidate for potassium deficiency.

Dehydration, as shown by Elkinton,, winkler et al. [13, 14, 26] is a major factor in promoting excessive potassium loss. Subsequent rehydration with normal saline solution alone further increases and stimutales this potassium shift and potassium deficit. This has been demonstrated by Darrow [12], Butler [7] and others [15, 19, 20]. G. I. T. losses may be a primary route for considerable loss of potassium, as is evident from the study of these cases. These findings are coraborrative of the findings of Randall and Lockwood [21, 22]. The extent of loss in experimental animals has been well illustrated by Abbot, Mallor and Muntwyler, [2, 3, 4] in their experimental work on dogs.

Prolonged and extesive tissue damage is directly proportional to the extent of potassium loss. Minor surgical procedure have a proportionately less potassium loss. This fact coincides with the findings of Berry [6] and Coopar [10]. This is due to liberation of potassium from the cells into extra cellular fluid and its ultimate excretion in urine is directly proportional to tissue damage. In this study, the findings go in conformation with the report of job and her coworkers[17] that in minor surgical procedures placing a patient on I. V. fluid therapy has more of an effect potassium loss than does the operation itself.

Those cases undergoing theracoplasty, subtotal thyroidectomy and partial gastrectomy showed a greater fall in their serum potassium compared to those undergoing herniorrhaphy or appendectomy [6, 15, 21, 22]. In the absence of potassium intake during and after operation and a continuous excretion of potassium in urine, two more factors play a major role in the potassium metabolism.

Firstly, the greater the surgical trauma, greater is the tissue destruction and release of potassium from the destroyed cells. It has been calculated by previous workers that for 1 gm. of Nitrogen 3 m. Eq./L of potassium is liberated and excreted in urine [18, 27]. This potassium from the tissue breakdown is released with the extracallular fluid to be finally excreted. The role of adrenal cortex in surgical trauma is the second important portant factor. Greater surgical trauma leads to a greater adrencortical response [23, 24, 25]. Adrenocorticoids stimulate potassium excretion and sodium conservation [8, 9]. Adrenal corticoids also stimulate release of potassium from muscle tissue into the extracellular fluid to be finally excreted in urine. Adrenocortical stimulation is directly proportional to the severity of operative procedure leading on a proportional potassium excretion.

Further, relationship between severity of operation and potassium deficiency is complicated by gastric suction I. V. Fluid therapy. Normal saline results in greater retention of sodium which is transferred into the cells and greater loss of potassium—Gibbs Donnan phenonemon [13] 5 per cent glucose also causes potassium through diuresis. [5, 10, 11].

In two cases of acute intestinal obstruction the initial pre-operative serum potassium was normal (4.2 and 5.0 m. Eq./L) but they showed a maximum post operative serum potassium fall (1.7 and 2.0 m. Eq./L). This can be explained as follows:

(i) Normal preoperative serum potassium may due to contraction of extra cellular fluid volume due to dehydration.

(ii) Pre-operative rehydration was done by saline. This must have caused a fall in serum potassium but it did not manifest. Another sample of blood was not examined after rehydration.

(iii) Gastric suction and operative trauma with increased post operative excretion of potassium in urine precipitared the potassium deficiency and both these cases manifested a maximum degree of potassium deficiency and died on 3rd and 4th day.

In most of the cases after operation of any severity there was a definite fall in serum potassium but it was not sufficient to produce clinical manifestation of hypopotassemia. Even partial gastrectomy with an average loss of 200 m. Eq. of potassium produced mild hypopotassemia.

In general, clinical manifestations of mild hypopotassemia appear at 3.2 m. Eq./L. and severe at 2.5 m. Eq./L or below. These cases improve rapidly when oral feeding is started as has been described by Ariel, Randal and Lockwood [21, 22] and other workers [15, 18, 27]. Their blood chemistry returns to normal within 4 to 6 days after starting oral intake of food.

ENTOMOLOGICAL SURVEY OF THE HIMALAYA

Part XXXI.—NEW AND LITTLE KNOWN STONEFLIES (PLECOPTERA) FROM THE NORTH-WEST (PUNJAB) HIMALAYA COLLECTED BY PROF. MANI'S THIRD ENTOMOLOGICAL EXPEDITION*

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Prof. M. S. Mani's Third Entomological Expedition to North-West Himalaya collected eight holognathous species of stone-flies, six of which are reported in an earlier paper (*Jewett*, 1958), dealing with the Plecoptera taken by the Second Entomological Expedition to the same area. Two remarkable new species of *Capnia* are contained in the present collection, particularly noteworthy because of the apterous condition of the males.

A detailed and excellent account of the Third Expedition's itinerary and activities has been published by Dr. Santokh Singh (1958). Dr. M. S. Mani has given a lucid account of the studies undertaken by himself and his colleagues on the high altitude insects of the North-West Himalaya (1957).

The stonefly material taken by the Third Expedition is recorded on the following pages. Most of the specimens are to be deposited in the collection of the Zoological Survey of India, Calcutta. A few are deposited in writer's collection (SGJ, JR).

NEMOURIDAE

TAENIOPTERGINAE

1. **Rhabdiopteryx lunata** Kimmins

1946. *Rhabdiopteryx lunata,* Kimmins, pp. 722—724.
1958. *Rhabdiopteryx lunata,* Jewett, p, 320

Material examined : Purana Khoksar Nal, 3500 metres, Chandra Valley, 12-vi-56, Santokh Singh, 2 females.

CAPNIINAE

2. **Capnia manii** Jewett

1958. *Capnia manii,* Jewett, pp. 321—323.

Material examined : Marhi, 3400 metres, River Beas, 28-v-56, V.K. Gupta, 4 females (2 females, SGJ, JR); Kulti Nal, 3660m, 8-vi-56, V.K. Gupta, 6 males, 5 females (3 males, 2 females, SGJ, JR); Kulti Nal 3540 m, 8-vi-56,

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*Part XXX of this series appeared in the *Agra University Journal of Research* Science) 9 (1): 65-88 (1960).

R. L. Kotpal, 5 males, females; Kulti Nal, 3700 m, Chandra Valley, 8-vi-56 Santokh Singh, male, female (SGJ, JR).

3. **Capnia gibbera** Jewett, new species

Length of body: holotype and paratype males, 8 mm.

General color light brown. Head through compound eyes as wide as greatest width of pronotum; lateral ocelli about as close to one another as to compound eyes; three ocelli forming an equilateral triangle. Pronotum longer than wide, slightly wider rearward, angles rounded evenly pigmented. Wings wholly lacking. First eight abdominal segments without special structures. Ninth sternite without lobe. Ninth tergite greatly swollen to form elevated hump that projects slightly rearward and possesses unsclerotized area dorsocaudally, on summit of which rests tip of supra-anal process. Supra-anal process of tenth tergite elongated in lateral view, slightly swollen on apical half with blunt tip, somewhat spatulate with rounded tip in dorsal view (fig. 1). Subanal plates narrow, curving rearward, their inner margins fused together.

Holotype male and one male *paratype*. Purana Khoksar Nal, 3600m, Chandra Valley, 12-vi-56, Santokh Singh. Paratype in author's collection.

The male genitalia of this species are quite unlike that of other described species of *Capnia*. The two known male specimens are completely apterous.

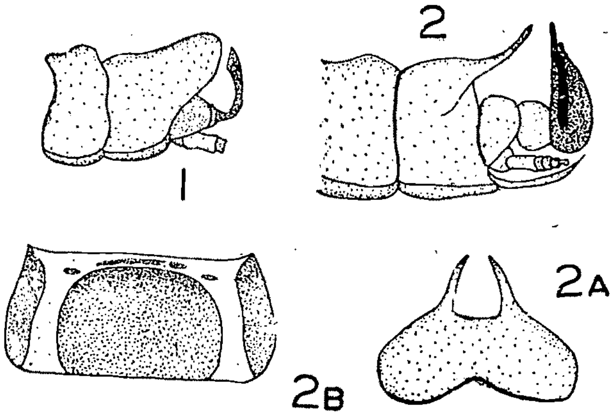

Fig. 1. *Capnia gibbera*, lateral view of paratype male genitalia. Fig. 2. *Capnia bifida*, lateral view of paratype male genitalia : 2A. dorsal view of ninth tergite, 2B. eighth sternite of allotype female.

4. **Capnia bifida** Jewett, new species

Length to wing tips : allotype and paratype females 14 mm. Length of body : holotype and paratype males 8 mm; allotype and paratype females 11 mm.

General color brown, wings of female with fumose bands. Head through compound eyes not quite as wide as greatest width of pronotum; lateral ocelli closer to compound eyes than to each other; 3 ocelli forming equilateral triangle. Pronotum slightly wider than long, widest rearward, all angles rounded, evenly pigmented but darker in females. Males wholly apterous. Venation of wings of females typical for genus, with sharp bend in first anal vein; forewing with irregular, narrow apical clear band followed by broad, irregular, fumose band clear band and inner area largely fumose; hind wing mostly fumose with irregular, clear spots distally in costal area and below stigma; stigma darkened in both wings. Cerci many segmented.

Male.—First eight abdominal segments without special structures. Heavy sclerotized bands on anterior borders of segments 2 to 10, incompletely formed medially on segments 2 to 5; pair of small brown median spots on tergites 2 to 8; large brown spot lateral to small spot on each of these segments. Outside corners ninth tergite drawn out to form long, slender, round processes which extend rearward and are slightly upturned (fig. 2). Ninth sternite without lobe. Supra-anal process of tenth tergite elongated, thick, heavily sclerotized, peg-like tip set off from rest of apical portion; widened in dorsal view, tip sharply tapering, blunt apically. Subanal plates forming almost equilateral triangle, inner margins fused apically to form long, narrow median process.

Female.—Distinctly larger than male and with fully developed wings. Subgenital plate on eighth abdominal sternite simple but well sclerotized, distal border slightly recessed from sides of sternite, broad, slightly rounded (almost truncate((fig. 2B). Eighth sternite of paratype without well-pigmented, dark marks beyond distal margin of subgenital plate as on sternite of allotype. Median membranous stripe extended from tergite 1 through 8.

Holotype male, *allotype* female, and single male and female *paratypes*, Kulti Nal 3,660 m, 8-vi-56, V.K. Gupta. Paratypes in author's collection.

Of described species of *Capnia*, this species bears closest resemblance to *Capnia pedestris* Kimmins (1946) described from Rongbuk Glacier, Mt. Everest, at an elevation of 5030 m. It differs in the male in being wholly apterous, in having spike-like rather than spatulate processes on the ninth tergite, and in details in the shape of the supra-anal process.

NEMOURINAE

5. **Nemoura cordata** Jewett

1958. *Nemoura cordata*, Jewett, p. 424.

Material examined : Glacier stream near Marhi, 24-v-56, Santokh Singh, male and female.

6. **Nemoura punctata** Jewett

1958. *Nemoura punctata*, Jewett, pp, 324—326.

Material examined : Marhi 3700 m, 26-v-56, V. K. Gupta, female; same except 25-v-56, Santokh Singh, 2 males, female (SGJ, JR); Marhi, 3660 m, 26-v-56, Santokh Singh, 2 males, female; Kulti Nal, 37000 m, Chandra Valley, 8-vi-56, Santokh Singh, male (SGJ, JR).

7. **Nemoura punjabensis** Jewett

1958. *Nemoura punjabensis*, Jewett, pp, 326—327.

Material examined : Kulti Nal 3660 m, 8-vi-56, V. K. Gupta, 5 males; Kulti Nal 3540 m., 8-vi-56, R. L. Kotpal, 2 males, female; Purana Khoksar Nal 3500 m., Chandra Valley, 12-vi-56, Santokh Singh, 10 males, 3 females (5 males, female, SGJ, JR).

In the original description of this species I failed to note that it is quite unlike any described species of *Nemoura*. The shape of the cerci and the supra-anal process, together with the vestigial lobe on the ninth sternite readily diffrentiate it from other Nemourids.

8. **Nemoura tricantha** Jewett

1958. *Nemoura tricantha*, Jewett, pp, 327—328,

Material examined : Manali, 2000 m, i-viii-56, V.K. Gupta, 3 females (1 female, SGJ, JR).

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A COMPLEX INVERSION FORMULA FOR A GENERALIZED STIELTJES TRANSFORM

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1. INTRODUCTION

A Stieltjes transform is an iterated Laplace transform. If

$$f_0(s) = \int_0^\infty e^{-st}\psi(t)\,dt$$

where

$$(1{\cdot}1) \qquad \psi(s) = \int_0^\infty e^{-st}\phi(t)\,dt,$$

then

$$(1.2) \qquad f_0(s) = \int_0^\infty \frac{\phi(t)\,dt}{s+t}$$

and this last equation is referred to as the Stieltjes transform.

Varma [4] has given a generalization of Laplace transform in the form

$$(1.3) \qquad f(s) = \int_0^\infty (st)^{m-\frac{1}{2}} e^{-\frac{1}{2}st} W_{k,m}(st)\psi(t)\,dt.$$

where $W_{k,m}$ stands for Whittaker function. He has also given two forms for the analogue of Stieltjes transform. If $f(s)$ is given by (1.3) and $\psi(s)$ by (1.1) we have.

$$(1{\cdot}4) \quad f(s) = \frac{\Gamma(2m+1)}{\Gamma(m-k+\frac{3}{2})} \frac{1}{s}\int_0^\infty F\left[\begin{matrix}2m+1.1\\ m-k+\frac{3}{2}\end{matrix}; -\frac{t}{s}\right]\phi(t)\,dt$$

where Re $(2m+1) > 0$. If $f_1(s)$ is the ordinary Laplace Transform of $\psi_1(t)$ and $\psi_1(s)$, the generalized Laplace transform of $\phi_1(t)$, we have

$$(1.5) \quad f_1(s) = \frac{\Gamma(2m+1)}{\Gamma(m-k+\frac{3}{2})}\int_0^\infty \frac{1}{t} F\left[\begin{matrix}2m+1,1\\ m-k+\frac{3}{2}\end{matrix}; -\frac{s}{t}\right]\phi_1(t)\,dt,$$

where $\text{Re}(2m+1) > 0$. By suitable change of variables (1·5) may be reduced to (1·4) and vice-versa.

If $k+m=\frac{1}{2}$, both (1.4) and (1.5) reduce to (1.2).

If $k-m=\frac{1}{2}$, $2m+1=\rho$, (1.4) reduces to the form

$$(1.6)\ X(s) = \frac{1}{\Gamma(\rho)}\, s^{-\rho+1} f(s) = \int_0^\infty \frac{\phi(t)\,dt}{(s+t)^\rho}$$

which is a generalization of Stieltjes transform.

In this paper we give complex inversion formulae for (1.4) and (1.6).

2. Complex Inversion Formulae

Theorem 1. If $f(s)$ is defined by (1·4), then

$$(2\cdot1)\quad \phi(v) = \frac{v^{m-1}}{\pi i} \int_{c-i\infty}^{c+i\infty} G(y)\, I_{2m}(yv^{-\frac12})\, y^{\frac12}\, dy,$$

where

$$G(y) = \int_0^\infty B(s,y)\, f(s)\, ds$$

and

$$B(s,y) = 2^{m+k-\frac52}\, y^{-m-k+1}\, s^{\frac12(k-m)-\frac54}\, J_{m-k+\frac12}(y/\sqrt{s})$$

provided that

(i) $\mathrm{Re}\,(2m+1) > 0$,

(ii) $0 < \mathrm{Re}(m-k+\frac32) < 2\max\{\mathrm{Re}(2m+1),1\} - \frac12$,

(iii) $\int_0^\infty t^{-\delta}\phi(t)\, dt$ converges, where $0 \leqq \delta < \min\{\mathrm{Re}\,(2m+1), 1\}$,

(iv) conditions of complex inversion formula of K_{2m}—transform [3] are satified by $G(y)$ and $u^{2m-\frac32}\phi(u^{-2})$, if $G(y)$ is K_{2m} – transform of $u^{2m-\frac32}\phi(u^{-2})$ in the sense,

$$G(y) = \int_0^\infty K_{2m}(yu)\,(yu)^{\frac12}\, u^{2m-\frac32}\phi(u^{-2})\, du.$$

(K denotes Bessel Function of the second kind for imaginary argument)

Proof: We have

$$G(y) = \int_0^\infty B(s,y)\, f(s)\, ds.$$

$$= 2^{m+k-\frac52}\, y^{-m-k+1} \frac{\Gamma(2m+1)}{\Gamma(m-k-\frac32)} \int_0^\infty s^{\frac12(k-m)-\frac94}\, J_{m-k+\frac12}(y/\sqrt{s})$$

$$ds \int_0^\infty F\left[{2m+1,1 \atop m-k+\frac{3}{2}}; -\frac{t}{s}\right] \phi(t)dt\,;$$

$$=2^{m+k-\frac{5}{2}} y^{-m-k+1} \frac{\Gamma(2m+1)}{\Gamma(m-k+\frac{3}{2})} \int_0^\infty \phi(t)dt \int_0^\infty F\left[{2m+1,\ 1 \atop m-k+\frac{3}{2}}; -\frac{t}{s}\right]$$

$$s^{\frac{1}{2}(k-m)-\frac{9}{4}} \mathcal{J}_{m-k+\frac{1}{2}}\left(\frac{y}{\sqrt{s}}\right) ds$$

on changing the order of integration.

$$= \int_0^\infty K_{2m}(yu)(yu)^{\frac{1}{2}} \phi(u^{-2})\, u^{2m-\frac{3}{2}}\, du,$$

provided that $0<\mathrm{Re}(m-k+\frac{3}{2})<2 \max\{\mathrm{Re}\,(2m+1),1\}-\frac{1}{2}$, since [2, page 81]

$$\int_0^\infty x^{\nu+1} F\left[{\alpha,\ \beta \atop \nu+1}; -\lambda^2x^2\right] \mathcal{J}_\nu(xy)dx = \frac{2^{\nu-\alpha-\beta+2}}{\lambda^{\alpha+\beta}}$$

$$\frac{\Gamma(\nu+1)}{\Gamma(\alpha)\Gamma(\beta)} y^{\alpha+\beta-\nu-2} K_{\alpha-\beta}(y\lambda^{-1})$$

provided that $-1<\mathrm{Re}\,\nu<2 \max\{\mathrm{Re}\,\alpha, \mathrm{Re}\,\beta\}-\frac{3}{2}$, $\mathrm{Re}\ \lambda>0$.

Applying Meijer's inversion formula for K-transform, we have

$$u^{2m-\frac{3}{2}} \phi(u^{-2}) = \frac{1}{\pi i} \int_{c-i\infty}^{c+i\infty} G(y) I_{2m}(yu)\,(yu)^{\frac{1}{2}}\, dy.$$

and from which (2.1) follows.

To justify the change in the order of integration, let us set

$$H(s,t) = t^{\delta} s^{-\varepsilon} F\left[{2m+1,\ 1 \atop m-k+\frac{3}{2}}; -\frac{t}{s}\right]$$

where $0\leqq\delta<\min\{\mathrm{Re}\,(2m+1),\ 1\}$ and $0\leqq\varepsilon\leqq\max\{\mathrm{Re}(2m+1), 1\}$

Using the asymptotic expansion of hypergeometric function [1, page 75] we can show that $H(s, t)$ is a continuous function of both s and t in $(0,\infty)$.

Also the integral

$$\int_0^\infty s^{\frac{1}{2}(k-m)-\frac{9}{4}+\varepsilon} \mathcal{J}_{m-k+\frac{1}{2}}(ys^{-\frac{1}{2}})\, ds = 2y^{-2-\mu+2\varepsilon}$$

$$\int_0^\infty u^{\mu+1-2\varepsilon} \mathcal{J}_\mu(u)du. \quad (\mu=m-k+\tfrac{1}{2})$$

converges provided that

$$\varepsilon > \frac{\mu^1}{2}+\frac{3}{4} \quad \text{and} \quad \mu'+1>\varepsilon \qquad (\mu' = \mathrm{Re}\ \mu),$$

or $2 \max \{\mathrm{Re}\,(2m+1), 1\} - \frac{1}{2} \geqq 2\varepsilon - \frac{1}{2} > \mathrm{Re}(m-k+\frac{3}{2}) > \varepsilon \geqq 0$,
or $2 \max \{\mathrm{Re}\,(2m+1), 1\} - \frac{1}{2} > \mathrm{Re}\,(m-k+\frac{3}{2}) > 0$;

since
$$\mathcal{J}_{\nu}(u) = 0(u^{-\frac{1}{2}}) \quad (u \to \infty),$$
$$= 0\,(u^{\nu}) \quad (u \to 0).$$

Hence the change in the order of integration is justified under the conditions stated in the theorem.

COROLLARY 1.1 If $2\,m+1=\rho$ and $m-k+\frac{1}{2}=0$, we have :
If $X\,(s)$ is the generalized Stieltjes transform of $\phi\,(t)$ in the sense.

$$X(s) = \int_0^\infty \frac{\phi(t)dt}{(s+t)^\rho}.$$

then

$$\phi(v) = \frac{v^{\frac{1}{2}(\rho-3)}}{\pi i} \int_{c-i\infty}^{c+i\infty} G_1(y)\, \mathrm{I}_{\rho-1}(y\, v^{-\frac{1}{2}})\ y^{\frac{1}{2}}\, dy,$$

where

$$G_1\,(y) = \int_0^\infty B_1\,(s, y) X(s)\, ds,$$

and

$$B_1\,(s, y) = \frac{1}{\Gamma(\rho)}\, s^{-\rho}\ 2^{\rho-3} y^{\frac{3}{2}-\rho}\, \mathcal{J}_0(\,y/\sqrt{s}\,)$$

provided that

(i) $\mathrm{Re}\ \rho > \frac{1}{4}$,

(ii) $\int_0^\infty t^{-\delta}\phi(t)dt$ converges, where $0 \leqq \delta < \min\{1, \rho\}$,

(iii) conditions of complex inversion formula of $K_{\rho-1}$ – transform are satisfied by $G_1\,(y)$ and $u^{\rho-\frac{5}{2}}\phi(u^{-2})$, where $G_1\,(y)$ is $K_{\rho-1}$ – transform of $u^{\rho-\frac{5}{2}}\phi(u^{-2})$.

COROLLARY. 1.2. If $m=0, k=\frac{1}{2}$, we have :
If $f_0\,(s)$ is Stieltjes transform of $\phi\,(t)$ in the sense

$$f_0(s) = \int_0^\infty \frac{\phi(t)dt}{s+t}$$

then

$$\phi(v) = \frac{v^{-1}}{\pi i} \int_{c-i\infty}^{c+i\infty} G_2(y)\ \mathrm{I}_0(y v^{-\frac{1}{2}})\ y^{\frac{1}{2}}\, dy,$$

where

$$G_2(y) = \int_0^\infty B_2(s,y)\, f_0(s)\, ds.$$

and $B_2(s, y) = 2^{-2}\, y^{\frac{1}{2}}\, s^{-1} \quad J_0\left(\frac{y}{\sqrt{s}}\right)$

provided that

(i) $\int_0^\infty t^{-\delta}\, \phi(t)\, dt$ converges, where $1 > \delta \geqq 0$,

(ii) conditions of complex inversion formula of K_0 − transform are satisfied by $G_2(y)$ and $u^{-\frac{3}{2}}\ \phi(u^{-2})$, if $G_2(y)$ is K_0 − transform of $u^{-\frac{3}{2}}\ \phi(u^{-2})$

COROLLARY. 1.3. If $k+m=\frac{1}{2}$, then we have :

If

$$f_0(s) = \int_0^\infty \frac{\phi(t)\, dt}{s+t}$$

then

$$\phi(v) = \frac{v^{m-1}}{\pi i} \int_{c-i\infty}^{c+i\infty} G_3(y)\, I_{2m}(y v^{-\frac{1}{2}})\, y^{\frac{1}{2}}\, dy.$$

where

$$G_3(y) = \int_0^\infty B_3(s,y)\, f_0(s)\, ds,$$

and

$$B_3(s, y) = 2^{-2}\, y^{\frac{1}{2}}\ s^{-m-1}\ J_{2m}\left(\frac{y}{\sqrt{s}}\right)$$

provided that

(i) $\frac{5}{2} > \mathrm{Re}\,(2m+1 > 0$,

(ii) $\int_0^\infty t^{-\delta}\, \phi(t) dt$ converges, where $0 \leqq \delta < 1$,

(iii) conditions of the inversion formula of K_{2m} − transform are satisfied by $G_3(y)$ and $u^{2m-\frac{3}{2}}\, \phi(u^{-2})$, if $G_3(y)$ is K_{2m} − transform of $u^{2m-\frac{3}{2}}\, \phi(u^{-2})$.

COROLLARY. 1.4. If $k=m=\frac{1}{4}$, we have :

If

$$f_0(s) = \int_0^\infty \frac{\phi(t)\, dt}{s+t}$$

then

$$\phi(v) = \frac{v^{-\frac{1}{2}}}{2\pi i} \int_{c-i\infty}^{c+i\infty} G_4(y) e^{y v^{-\frac{1}{2}}} dy,$$

where

$$G_4(y) = \int_0^\infty B_4(s, y) f_0(s)\, ds,$$

and

$$B_4(s, y) = (2\pi s)^{-1} \sin\left(\frac{y}{\sqrt{s}}\right)$$

provided that

(i) $\int_0^\infty t^{-\delta} \phi(t)\, dt$ converges, where $0 \leqq \delta < 1$,

(ii) conditions of the inversion formula of Laplace transform are satisfied by $G_4(y)$ and $u^{-1}\phi(u^{-2})$, where $G_4(y) = \int_0^\infty e^{-uy} u^{-1} \phi(u^{-2})\, du$.

We now give an inversion formula for the transform (1.6) which can not be deduced as a corollary of the previous theorem.

Theorem 2. If $X(s)$ is given by (1.6), then

$$(2.2) \quad \phi(v) = \frac{v^{2\rho-1}}{\pi i} \int_{c-i\infty}^{c+i\infty} I_{\rho-\frac{1}{2}}(v^{\frac{1}{2}} y)\, y^{\frac{1}{2}}\, V(y)\, dy.$$

where

$$V(y) = \int_0^\infty A(s, y) X(s)\, ds,$$

and

$$A(s, y) = \Gamma(\rho)\, 2^{\rho-5/2} \pi^{-\frac{1}{2}} y^{1-\rho} s^{-\frac{1}{2}} \cos(y s^{\frac{1}{2}})$$

provided that

(i) $\int_0^\infty t^{-\delta} \phi(t)\, dt$ converges, where $1 > \delta \geqq 0$,

(ii) $\mathrm{Re}\, \rho > 0$,

(iii) conditions of complex inversion formula of $K_{\rho-\frac{1}{2}}$—transform are satisfied by $V(y)$ and $\phi(u^2) u^{1-\rho}$, where $V(y) = \int_0^\infty K_{\rho-\frac{1}{2}}(yu)(yu)^{\frac{1}{2}} \phi(u^2) u^{1-\rho}\, du$.

Proof : we have

$$V(y)=\int_0^\infty A(s,y)X(s)\,ds,$$

$$=\Gamma(\rho)\, y^{1-\rho}\pi^{-\frac{1}{2}}\, 2^{\rho-5/2}\int_0^\infty s^{-\frac{1}{2}}\cos(ys^{\frac{1}{2}})\,ds\int_0^\infty \frac{1}{(s+t)^\rho}\phi(t)\,dt,$$

$$=\Gamma(\rho)\, y^{1-\rho}\pi^{-\frac{1}{2}}\, 2^{\rho-5/2}\int_0^\infty \phi(t)\,dt\int_0^\infty s^{-\frac{1}{2}}\cos(ys^{\frac{1}{2}})\frac{1}{(s+t)^\rho}\,ds,$$

on changing the order of integration

$$=\int_0^\infty K_{\rho-\frac{1}{2}}(uy)\,(uy)^{\frac{1}{2}}\,u^{1-\rho}\phi(u^2)\,du.$$

since [2, page 234]

$$\int_0^\infty x^{-\frac{1}{2}}\cos(ax^{\frac{1}{2}})\frac{1}{(x+y)^\rho}\,dx=\frac{2\pi^{\frac{1}{2}}}{\Gamma(\rho)}\left(\frac{2y^{\frac{1}{2}}}{a}\right)^{\frac{1}{2}-\rho}K_{\rho-\frac{1}{2}}(ay^{\frac{1}{2}})$$

provided that Re $\rho > 0$ and Re $a > 0$.

Applying the complex inversion formula for $K_{\rho-\frac{1}{2}}$—transform, we have

$$\phi(u^2)\,u^{1-\rho}=\frac{1}{\pi i}\int_{c-i\infty}^{c+i\infty} I_{\rho-\frac{1}{2}}(uy)\,(uy)^{\frac{1}{2}}\,V(y)\,dy,$$

from which (2. 3) follows.

The change in the order of integration is justified in a manner similar to that of Theorem 1.

COROLLARY 2. 1: If $\rho=1$, we have :

If

$$f_0(s)=\int_0^\infty \frac{\phi(t)\,dt}{s+t},$$

then

$$\phi(v)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} e^{\frac{1}{2}y}\,V_1(y)\,dy,$$

where

$$V_1(y)=\int_0^\infty A_1(s,y)\,f_0(s)\,ds,$$

and

$$A_1(s,y)=\pi^{-\frac{1}{2}}\,2^{-\frac{3}{2}}\,s^{-\frac{1}{2}}\cos(y\,s^{\frac{1}{2}}),$$

provided that

(i) $\int_0^\infty t^{-\delta}\phi(t)\,dt$ converges, where $1 > \delta \geq 0$,

(ii) conditions of the inversion formula of Laplace transform are satisfied by $\phi(u^2)$ and $V_1(y)$,

where $V_1(y)=\int_0^\infty e^{-uy}\phi(u^2)\,du$.

3. EXAMPLES

Example 1. Let $\phi(t)=t^{\alpha-1}$.

Then

$$f(s)=\frac{\Gamma(2m-1)}{\Gamma(m-k-{}^3/_2)}\,\frac{1}{s}\int_0^\infty F\left[\begin{matrix}2m+1,\ 1\\ m-k+{}^3/_2\end{matrix};-t/s\right]\phi(t)\,dt,$$

$$=\frac{\Gamma(2m+1-\alpha)\,\Gamma(1-\alpha)\,\Gamma(\alpha)}{\Gamma(m-k+{}^3/_2-\alpha)}\,s^{\alpha-1}$$

provided that Re $(2m+1-\alpha)>0$, Re $(1-\alpha)>0$, Re $\alpha>0$, $m-k+\frac{3}{2}\neq 0, -1, -2, \ldots\ldots$

Therefore

$$G(y)=2^{m+k-\frac{5}{2}}\,y^{-m-k+1}\int_0^\infty s^{\frac{1}{2}(k-m)-\frac{5}{4}}\,J_{m-k+\frac{1}{2}}\left(\frac{y}{\sqrt{s}}\right)f(s)\,ds,$$

$$=\frac{\Gamma(2m+1-\alpha)\,\Gamma(1-\alpha)\,\Gamma(\alpha)}{\Gamma(m-k+\frac{3}{2}-\alpha)}\,2^{m+k-\frac{3}{2}}y^{-m-k+1}\int_0^\infty u^{m-k+\frac{3}{2}-2\alpha}\,J_{m-k+\frac{1}{2}}(yu)\,du.$$

$$=\Gamma(1-\alpha)\,\Gamma(2m+1-\alpha)\,2^{2m-2\alpha}\,y^{2\alpha-2m-\frac{3}{2}},$$

provided that Re $(m-k+{}^3/_2-\alpha)>0$, Re $(m-k+{}^3/_2-2\alpha)<0$, since [2, page 22]

$$\int_0^\infty J_\nu(xy)\,x^{\mu+\frac{1}{2}}\,dx=2^{\mu+\frac{1}{2}}\,y^{-\mu-\frac{3}{2}}\,\frac{\Gamma(\frac{1}{2}\mu+\frac{1}{2}\nu+\frac{3}{4})}{\Gamma(\frac{1}{2}\nu-\frac{1}{2}\mu+\frac{1}{4})},$$

provided that Re $(y)>0$, and $-$Re $\nu-\frac{3}{2}<$ Re $\mu<-\frac{1}{2}$.

Also

$$u^{2m-\frac{3}{2}}\,\phi(u^{-2})=u^{2m-2\alpha+\frac{1}{2}}$$

and

$$\int_0^\infty K_{2m}(yu)\,(yu)^{\frac{1}{2}}\,u^{2m-2\alpha+\frac{1}{2}}\,du$$

$$=2^{2m-2\alpha}\,\Gamma(1-\alpha)\,\Gamma(2m+1-\alpha)\,y^{2\alpha-2m-\frac{3}{2}},$$

since [2, page 127]

$$\int_0^\infty x^{\rho-1}\,K_\nu(xy)\,(xy)^{\frac{1}{2}}\,dx=2^{\rho-\frac{3}{2}}y^{-\rho}\,\Gamma\left(\frac{\rho}{2}+\frac{\nu}{2}+\frac{1}{4}\right)\times\Gamma\left(\frac{\rho}{2}-\frac{\nu}{2}+\frac{1}{4}\right).$$

provided that Re $\rho>|$Re $\nu|-\frac{1}{2}$, Re $y>0$.

Thus we shown that G (y) is $K-$transform of order $2m$ of $u^{2m-\frac{3}{2}}\,\phi(u^{-2})$.

Example 2. Let $\phi(t)=\sin(a\,t^1/^2)$ $(a>0)$.

Then

$$X(s)=\int_0^\infty \frac{\phi(t)\,dt}{(s+t)^p}$$

$$=\frac{1}{\Gamma(p)}\,2^{\frac{3}{2}-p}\,a^{p-\frac{1}{2}}\,\pi^{\frac{1}{2}}\,s^{\frac{3}{4}-\frac{1}{2}p}\,K_{p-\frac{3}{2}}\left(a s^{\frac{1}{2}}\right),$$

by using the result [2, page 234].

$$\int_0^\infty \frac{\sin\left(ax^{\frac{1}{2}}\right)dx}{(x+y)^p}=\frac{2\pi^{\frac{1}{2}}\,y^{\frac{1}{2}}}{\Gamma(p)}\left(\frac{2y^{\frac{1}{2}}}{a}\right)^{\frac{1}{2}-p}K_{p-\frac{3}{2}}\left(a y^{\frac{1}{2}}\right).$$

provided that Re $a > 0$ and Re $p > \frac{1}{2}$.

Therefore

$$G_1(y)=2^{-\frac{3}{2}}\pi^{\frac{1}{2}}\,a^{p-\frac{1}{2}}\,y^{\frac{3}{2}-p}\int_0^\infty s^{\frac{1}{2}p-\frac{5}{4}}\,\mathcal{J}_0\left(\frac{y}{\sqrt{s}}\right)K_{p-\frac{3}{2}}\left(a s^{\frac{1}{2}}\right)ds,$$

$$=2^{p-\frac{3}{2}}\,\pi^{\frac{1}{2}}\,y^{-p+\frac{3}{2}}\,G^{30}_{04}\left(\frac{a^2y^2}{16}\,\middle|\,0,p-1,\tfrac{1}{2},0\right),$$

since [2, pages 375]

$$(3.1)\qquad \int_0^\infty x^{p-1}K_\mu(\alpha x)\,\mathcal{J}_\nu\left(bx^{-1}\right)dx$$

$$=2^{p-\frac{1}{2}}\,\alpha^{-p}\,G^{30}_{04}\left(\frac{\alpha^2b^2}{16}\,\middle|\,\frac{\nu}{2},\frac{p+\mu}{2},\frac{p-\mu}{2},-\frac{\nu}{2}\right).$$

provided that Re $b>0$, Re $\alpha > 0$, Re $p > |\operatorname{Re}\mu| -\frac{3}{2}$.

Also $u^{p-\frac{5}{2}}\,\phi\left(u^{-2}\right)$

$$=u^{p-\frac{5}{2}}\sin\left(a u^{-1}\right),$$

and

$$\int_0^\infty K_{p-1}(yu)\,(yu)^{\frac{1}{2}}\,u^{p-\frac{5}{2}}\,\phi\left(u^{-2}\right)du$$

$$=a^{\frac{1}{2}}\,\pi^{\frac{1}{2}}\,2^{p-\frac{5}{2}}\,y^{2-p}\,G^{30}_{04}\left(\frac{a^2y^2}{16}\,\middle|\,\frac{1}{4},p-\frac{5}{4},-\frac{1}{4},-\frac{1}{4}\right)$$

(by using (3. 1) and remembering $\mathcal{J}_{\frac{1}{2}}(z)=(2/\pi z)^{\frac{1}{2}}\sin z$)

$$=\pi^{\frac{1}{2}}\,2^{p-\frac{3}{2}}\,y^{\frac{3}{2}-p}\,G^{30}_{04}\left(\frac{a^2y^2}{16}\,\middle|\,0,p-1,\tfrac{1}{2},0\right)$$

$$=G_1(y)$$

since [1, page 209]

$$(3.2)\qquad x^\sigma\,G^{mn}_{pq}\left(x\,\middle|\,\begin{matrix}a_r\\ b_s\end{matrix}\right)=G^{mn}_{pq}\left(x\,\middle|\,\begin{matrix}a_r+\sigma\\ b_r+\sigma\end{matrix}\right)$$

Thus we have shown that $G_1\,(y)$ is the K-transform of order $p-1$ of $u^{p-\frac{5}{2}}\,\phi\,(u^{-2})$.

Example 3. Let $\phi\,(t)=t^{\nu/2}\,J_\nu\,(\alpha t^{\frac{1}{2}})$ Re $\alpha>0, -1<\text{Re}\,\nu<\frac{3}{2}$

Then [2, page 225]

$$o\,(s)=\int_0^\infty \frac{\phi\,(t)\,dt}{s+t}$$

$$=2^{\frac{1}{2}\nu}\,K_\nu\,(\alpha\,s^{\frac{1}{2}}).$$

Therefore

$$G_4\,(y)=2^{-\frac{3}{2}}\,y^{\frac{1}{2}}\,\pi^{-\frac{1}{2}}\int_0^\infty s^{-\frac{5}{4}}\,J_{\frac{1}{2}}\,(y/\sqrt{s})\,f_0\,(s)\,ds,$$

$$=\pi^{-\frac{1}{2}}y^{\frac{1}{2}}\;2^{\nu-\frac{1}{2}}\,\alpha^{-\nu+\frac{1}{2}}\,G^{30}_{04}\left(\frac{\alpha^2 y^2}{16}\;\middle|\;\frac{1}{4},\,\nu-\frac{1}{4},-\frac{1}{4},-\frac{1}{4}\right)$$

provided that Re $y>0$, Re $(-\nu+\frac{1}{2})>|\,\text{Re}\,\nu\,|-\frac{3}{2}$ (by using (3. 1))

$$=2^{\nu+\frac{1}{2}}\,\pi^{-\frac{1}{2}}\,\alpha^{-\nu}\;G^{30}_{04}\left(\frac{\alpha^2 y^2}{16}\;\middle|\;\frac{1}{2},\nu,0,0\right),$$

by using (3. 2).

Also

$$u^{-1}\phi\,(u^{-2})=u^{-\nu-1}\;J_\nu\,(\alpha\,u^{-1}).$$

is the inverse Laplace transform of $G_4\,(y)$, since

$$\int_0^\infty e^{-yu}\,u^{-\nu-1}\;J_\nu\,(\alpha u^{-1})\,du$$

$$=\pi^{-\frac{1}{2}}\;2^{-\nu+\frac{1}{2}}y^{\nu}\,G^{30}_{04}\left(\frac{\alpha^2 y^2}{16}\;\middle|\;\frac{\nu}{2},\frac{1}{2}-\frac{\nu}{2},-\frac{\nu}{2},-\frac{\nu}{2}\right)$$

by using (3. 1).

$$=\pi^{-\frac{1}{2}}\,2^{\nu+\frac{1}{2}}\,\alpha^{-\nu}\;G^{30}_{04}\left(\frac{\alpha^2 y^2}{16}\;\middle|\;\frac{1}{2},\nu,0,0\right)$$

by using (3. 2).

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STUDIES ON THE KEEPING QUALITY OF CREAMERY BUTTER DURING STORAGE AT 40° F

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INTRODUCTION

Butter is an important energy source in human dietary and unlike vegetable fats and oils is an excellent and potent source of Vitamin A and D. Although the active principle in butter is butter-fat, whose calorific value per unit weight is higher than that of butter, the physical condition of the latter with its aroma and flavour makes it more palatable and easily digestible than the former. At ordinary temperatures, under household conditions specially in summer, it is a common experience that butter deteriorates very soon. This poses a problem for the Producers as well as Consumers and, therefore, calls for an intimate knowledge of the various factors concerned in prolonging the life of butter. Storgards (1950), recommended a medium acidity of cream ripening for higher keeping quality of butter and thus supported the view that if cream is allowed to develop high acidity as lactic acid, the intermediate compounds formed from lactic acid during storage shall accelerate the process of hydrolysis (Long, 1949).

Pont (1946), found that washed butter kept better than unwashed one at 16° F. White, Beattic and Riel (1956), however, found no significant difference in flavour quality of the comparable washed and non-washed butters before and after storage and reported a higher yield in non-washed butters because of the retention of higher curd content. Burgers (1938), after a study of large number of butter samples concluded that for good keeping quality, butter should contain from 1.3 to 1.7% salt. Hunziker (1940), also observed that higher the salt content of butter, lesser is the danger from flavour defects caused by bacteria. Mohr and Wallene (1948), however, reported that highly salted butter develops cracks in the body.

With this background, emphasising the practical application of the results, the present investigation was planned to study the keeping quality of butter stored at 40° F as influenced by the following popular variables :—

i. Acidity of cream,
ii. Number of washings given to butter, and
iii. Salt content of butter.

EXPERIMENTAL

The cream for the experiment was procured from the local market under personal supervision. It was standardised to 35% fat by adding separated milk. After pasteurization it was divided into three separate lots. The first lot was churned immediately in sweet condition, whereas the second and the third lots were churned after ripening to 0.45% and 0.75% serum acidity (as lactic acid) respectively by inoculating with market starter. All the technological steps during churning, including churning temperature, proportion and temperature of break and wash waters in each washing were kept identical in all the three lots.

Butters from the first and third cream lots were given two washings and salted at the rate of 2.0%. Butter from the second cream lot was divided into 4 lots each to be treated differently with respect to washing. The first being kept unwashed, the second, third and the fourth butter lots received one, two and three washings respectively. Second and fourth butter lots were salted at the rate of 2.0%. The remaining two lots, *viz*., unwashed butter and the butter with two washings were again divided into four lots each to receive no salt, 1.0% salt, 2.0% salt and 2.5% salt respectively.

Thus we had the samples of butter available for storage from the following treatments :

(i) 0.22% acid cream + 2 washings + 2.0% salt.
(ii) 0.45% acid cream + no washing + 2.0% salt.
(iii) 0.45% acid cream + 1 washing + 2.0% salt.
(iv) 0.45% acid cream + 3 washings + 2.0% salt.
(v) 0.45% acid cream + 2 washings + 0.0% salt.
(vi) 0.45% acid cream + 2 washings + 1.0% salt.
(vii) 0.45% acid cream + 2 washings + 2.0% salt.
(viii) 0.45% acid cream + 2 washings + 2.5% salt.
(ix) 0.75% acid cream + 2 washings + 2.0% salt.

All the samples of butter were stored in packets of 1 oz. each at 40° F and were analysed after every 7 days interval for physical characteristics, acid value and the peroxide value.

RESULTS AND DISCUSSION

Effect of acidity of cream on flavour and keeping quality of butter stored at 40°F :—

It is obvious from Table I that flavour of fresh butter is greatly influenced by the ripening of cream. Ripening cream to 0.45% serum acidity induces pronounced desirable flavour, while 0.75% tends to impart butter slightly acidic taste. These findings are in agreement with those of Hunziker (1940), who also noted acid and sour flavour from over-ripened cream butters. Besides, production of acidity, the addition of starter produces diacetyl, acetyl-methyl-carbinol, acetic and propionic acids, the flavouring substances of butter. Thus a better flavoured product is obtained by ripening to 0.45% serum acidity. Flavour spoilage in both unripened and ripened cream butters was most probably due to oxidation of butter fat. It was rapid in later stages in ripened cream butters, due to the activity of mould giving rise to mould rancidity.

The effect of cream acidity on the acid value of fresh and stored butter as shown in Table I indicate that the acidity in butter increases with the increase in acidity of cream. The lowest acid value of 0.12 was observed in unripened cream and the highest value of 0.48 in case of butter from cream ripened to 0.75% serum acidity. The highest value of 0.57 was reached in butter from cream of 0.45% serum acidity in 35 days, while the peak value of 0.70 in unripened and ripened to 0.75% serum acidity was reached at a storage period of 28 and 14 days respectively. There was a constant decline in acid values of different butters after the peak value was reached. This is contrary to the findings of Davies (1941), who reported that acid value in butter increased during the storage. This may probably be due to the fact, that during this period considerable amount of fatty acids were consumed by yeasts and moulds which prefer to have an acid medium for their normal growth.

The peroxide values of unripened as well as ripened cream butters also increased during storage upto 14 days (Table I). The increase remained proportional to the serum acidity of the cream, being the least (2.10) in unripened and the highest (3.6) in over-ripened cream butter. This finding suggests a slower rate of oxidation of butter-fat from low acid cream than from high acid one. It seems, therefore, that there is an inverse relationship between the keeping quality of butter as reflected by its peroxide value and the ripening acidity of cream, suggesting thereby that butter from unripened cream has got superior keeping quality. This finding is in keeping with that of several earlier Australian and New Zealand workers.

Effect of washings of butter on its flavour and keeping quality :—

The results shown in Table II indicate that unwashed fresh butter gave pronounced diacetyl flavour, while the intensity of flavour decreased with an increase in the number of washings. The mild flavour in case of excessively washed butter can easily be attributed to the excessive removal of flavouring substances and reduction in the curd content. That high curd content gives the best score has been shown by Wiley (1946) and Dyascheuko (1950). However, this view does not find support from White and Coworkers (1956).

Both, unwashed and once washed butters, were equally prone to deterioration after a storage period of 28 days, while twice and thrice washed butters developed the same defect after 35 days. The early development of off flavours in unwashed butter may be due to higher content of acidity in fresh butter, which enhances the hydrolysis of fat and production of free fatty acids. The same views were held by Pederson (1939), who considered thorough washing as an essential step in butter making. This view is, however, opposed byNew Zealand, Denmark, Australian and Canadian workers (Jensen, Wiley, 1942 ; Medowall, Pont, 1946-48 and Riel and White, 1956), who consider washing to be an unnecessary step. The acid value of washed and unwashed butters as shown in Table II present a characteristic picture. The highest value of 0.42 in fresh butter was found in twice washed butter followed by 0.39 in thrice washed butter. On the other hand the values for the other two samples *i.e.*, unwashed and once washed butters were only 0.33 and 0.30 respectively. This shows that washing may not have any effect on initial acidity of butter. Unwashed butter exhibited comparatively low acid values during storage probably because of some antioxidant effect of curd in them.

The peroxide values in various washed and unwashed butters as shown in Table II exhibited no difference in the initial stages. The values, however, increased during storage. At the storage period of 14 days peroxide values of different samples increased to 2.1 in unwashed butter and 2.8, 2.9 and 2.9 in once, twice and thrice washed butters respectively. A decrease was, however, found during storage on the 21st day. Unwashed and once washed butters showed a decrease of 28.6% over the value of the 14th day, while the decrease in case of twice and thrice washed butters was 31.02%. The initial relatively smaller increase in Peroxide value under no washing and one washing may possibly be due to the increased curd percentage retained in these samples, protecting fat from ready oxidation. On the other hand under high washings the possible contamination by wash-water might have brought about increased oxidation. From all these findings it is clear that excessive washings favoured increased oxidation of butter fat lowering its keeping quality as has also been suggested by Jensen (1942), Newman (1946) and Pont (1948).

Effect of Per cent salt added on the flavour and keeping quality of butter stored at 40°F:—

It is observed from Table III that salt content of butter has no adverse influence on the flavour of fresh butter, except that 2.5% salt gave salty taste, while 1·0% and 2.0% salt appealed to palate. Unsalted butter gave distinct diacetyl flavour. Burgers (1938) also suggested that for good taste butter should contain 1.3 to 1.7% salt. After a storage period of 21 days, defects started to develop in unsalted and 1.0% salted butters, while there was no change in butters with 2.0 and 2.5% salt. In general the observation revealed that unsalted as compared with salted butter develops flavour defects earlier, showing thereby that salt enhances the keeping quality of butter. Salting of butter from high acid cream led almost inevitably to the development of fishy flavour.

Table I

Showing the effect of acidity of cream on the flavour and keeping quality of butter stored at 40°F.

Days in storage	0.22% Lactic Acid			0.45% Lactic Acid			0.75% Lactic Acid		
	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value
Fresh	Mild	0.12	0.30	Desirable	0.42	0.40	Desirable slightly acidic	0.48	0.60
7	Mild	0.54	2.10	do	0.60	2.50	do	0.69	3.00
14	Mild	0.60	2.56	do	0.66	3.60	do	0.70	3.60
21	Stale	0.61	2.20	Storage flavour	0.68	2.20	Storage flavour	0.57	2.70
28	Slightly Rancid	0.70	0.55	Slightly stale	0.70	1.50	Slightly stale	0.57	1.25
35	Rancid & foul smell	0.66	0.50	Quite stale	0.75	1.05	Slightly fishy	0.55	1.23
42	Quite Rancid & inedible	0.48	—	Rancid	0.62	0.85	Fishy off flavour	0.54	0.60
49	do	0.45	0.25	Rancid	0.60	0.30	Extremely fishy	0.52	0.60
56	do	0.42	0.25	Extremely Rancid	0.54	0.25	do	0.52	0.52
60	do	—	—	Fishy taint	0.50	0.25	do	—	—

Table II

Showing the effect of washings of butter on its flavour and keeping quality.

Days in storage.	Unwashed			One washing			Two washings			Three washings		
	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value
Fresh	Diacetyl	0.33	0.31	Diacetyl	0.30	0.31	Slightly flat	0.42	0.30	Mild	0.39	0.30
7	do	0.54	1.20	do	0.57	1.20	do	0.50	1.30	do	0.45	1.60
14	do	0.54	2.10	do	0.57	2.80	do	0.56	2.90	do	0.48	2.90
21	Storage mouldy	0.52	1.95	do	0.59	2.00	Slight defect	0.62	2.00	Rotten	0.55	2.10
28	Rancid	0.50	1.15	Mouldy	0.61	1.50	do	0.65	1.05	do	0.48	1.60
35	do	0.48	0.95	Stale	0.69	1.20	Quite Rancid	0.60	1.05	do	0.47	0.90
42	Quite Rancid	0.42	0.90	do	0.74	0.65	do	0.58	0.75	Quite Rotten	0.47	0.78
49	do	0.40	0.89	Rancid	0.61	0.50	do	0.50	0.65	Slight tallowy	0.40	0.68
56	Ext. Rancid inedible	—	0.78	do	0.51	0.48	Inedible	0.39	0.55	Extremely tallowy	0.42	0.62
60	Inedible	—	—	Extremely Rancid	—	0.50	Deteriorated	—	0.53	do	—	—

Table III

Showing the effect of Per cent. salt added on the flavour and keeping quality of butter stored at 40°F.

Days in Storage	Unsalted			1.0% salt			2.% salt			2.5% salt		
	Flavour	Acid value	Pero-xide value.	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value	Flavour	Acid value	Peroxide value
Fresh	Diacetyl	0.42	0.10	Diacetyl	0.39	0.20	Diacetyl	0.39	0.20	Diacetyl slightly salty	0.33	0.30
7	do	0.54	0.20	do	0.52	0.50	do	0.50	1.30	do	0.53	1.10
14	do	0.60	2.20	do	0.55	3.30	do	0.66	3.60	do	0.54	3.70
21	Slight defect	0.62	2·20	do	0.61	1.50	do	0.75	2.20	do	0.68	1.70
28	Slight Rancid	0.90	0.75	Slight Rancid	0.68	1.00	do	0.68	1.50	do	0.66	1.45
35	Rancid	0.73	0.45	Quite Rancid	0.67	0 60	do	0.45	1.05	do	0.61	1.20
42	do	0.50	0.45	do	0.38	0.40	Highly Rancid	0.42	0.57	Stale	0.50	1.00
49	Highly Rancid	0.40	0.37	do	0.40	0.38	do	0.37	0.55	Quite stale and fishy	0.56	0.90
56	Deteriorated inedible	-	-	do	-	0.32	Slightly fishy	-	0.30	Extremely fishy	0.60	0.40
60	do	-	-	do	-	-	Extremely fishy	-	0.32	do	0.60	0.38

The effect of different percentages of salt on the acid value of butter, as has been shown in Table III, indicates that it (acid value) was higher in unsalted butter (0.42) in comparison with the values for salted butters, which were 0.33, 0.39 and 0.39 in case of 1.0%, 2.0% and 2.5% salt respectively. Acid values of unsalted and highly salted butters in successive periods of storage were much more in comparison with lightly salted butters. The initial relatively low acid values in salted butters is probably due to the inhibiting effect of salt on the growth of micro-ogranisms, whereas in the later stages of storage salted butters exhibited high acid values, this being an accelerating effect of salt on the liberation of fatty acids. Shepard and Olson (1935) also found salted butter with better keeping quality than unsalted one, when stored for about a fortnight, while with an increase in storage period the acid values of salted butters increased more than in unsalted ones.

The effect of per cent. salt added to butter on its peroxide value is also shown in Table III. Peroxide values of the fresh samples indicate that it increases with increasing level of salt. It was the least in case of unsalted butter (0.10) and the highest (0.30) in 2.5% salted butter. During storage the values increased in all the samples, but the rate of increase in 2.0% and 2.5% salted butters was distinctly more than that in 1.0% salted and unsalted butters. A peak value of 3.7 was reached in case of highly salted butter at a storage period of 14 days. The subsequent analyses witnessed a gradual fall in all the butter samples. The reason why salted butters exhibited higher peroxide values in the initial stages and throughout the storage period is, that the oxidation of butter fat is accelerated in presence of salt (Wiley, 1937).

SUMMARY

An attempt was made to study the keeping quality of butter stored at 40° F as influenced by acidity of cream, washings of butter and salt percentages added. The results suggest that butter made from cream ripened to 0.45% serum acidity, kept unwashed with 2.0% salt gives best flavour and could be stored for 35 days, while unripened cream butter, kept unwashed with 2.0% salt gives increased keeping quality. It may, therefore, be recommended that for ready consumption and short storage, the former type and for long storage, the latter type of butter should get preference.

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A TECHNIQUE FOR DISEASE APPRAISAL AND LOSS ESTIMATION IN *FUSARIUM* WILT OF GRAM (*Cicer arietinum* L.)

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Introduction

Gram (*Cicer arietinum* Linn.) suffers greatly from wilt disease caused by *Fusarium orthoceras* App. & Wr. var. *ciceri* and also sometimes by *Rhizoctonia* and *Sclerotium rolfsii.* Certain cultural aspects of *Fusarium orthoceras* var. *ciceri* were studied by Padwick (1940). Padwick and Bhawagar (1943) observed the effect of sowing dates on the incidence of the *Fusarium* wilt. Preliminary studies of certain soil factors, physiologic variations of the parasite and also varietal resistance in relation to the disease were earlier made by the author (1956, 1957 & 1959). Recently Raheja and Das (1957) working on wilt of gram caused by *Fusarium orthoceras* var. *ciceri* have studied the interaction of the factors *viz,* date of sowing, depth of seedling, spacing between the rows and recorded observations in respect to germination, growth rate, flowering and incidence of wilt. The present paper deals with a technique developed to investigate disease intensity and crop-loss which was confined to a selected locality in Agra. That the wilt was caused by the same fungus (*Fusarium orthoceras* var. *ciceri*) was confirmed from a large number of isolations obtained from the diseased plants.

Methods and Materials

Observations were recorded during *rabi* 1955-56 at B. R. College, Bichpuri Farm, Agra. Plants from 'healthy' and 'diseased' units (each one yard long along the row), selected at random, were harvested from the field and brought carefully to the laboratory in separate packets where observations were recorded and the data analysed statistically.

Disease Intensity—The disease intensity was measured by reducing the visual observations of symptoms to a quantitative index depending upon the stage and extent of wilting. An entire plant is given a total score of 100 points. A plant perfectly healthy scores zero point, while a plant wilting in early stages scores 100 points of disease intensity. 80 points are scored if the plant wilts completely after flowering and 75 points when half the plant wilts in fairly early stages and the remaining half continues to be apparently healthy and produces pods (50 points given for wilting in early stages and 25 points for apparently healthy part which is also considered to be under overall influence of the disease), 25 points are scored if after pod formation half the plant wilts and the rest remains apparently healthy in view of the consideration that the overall influence of the disease is less after the pods have been formed.

The dry weight of grains from 'healthy' and 'diseased' units and losses due to the disease were recorded to calculate the correlation between the disease intensity and loss in yield.

Loss-Estimate—Chester's individual method (1950, pp. 295) for estimating the loss was adopted with the modification that instead of pairs of healthy and diseased individuals, small units in length, 'healthy' and 'diseased', covering about five per cent of the fields row were taken, each unit length measuring 3 feet. The unit having even one diseased plant was considered as diseased while in a healthy unit all the plants were disease free. The loss was estimated in gms. from the yields in 'healthy' and 'diseased' units as follows:

Loss in yield (in gms.) = Yh-Yd, where Yh is the yield of 'healthy' unit and Yd the yield of 'diseased' unit.

In order to determine whether the loss is significant, 't' values (Loss in yield/Standard error) were calculated. Similarly correlation coefficients ('r' values) between loss in yield and percentage of disease intensity were also estimated. Regression coefficients ('b' values) indicating loss in yield for unit increase in the disease intensity were also arrived at since 'r' values were found to be highly significant.

RESULTS

Observations recorded on hundred random units in both the fields are summarised below :

Table I

DISEASE, INTENSITY

Disease intensity in diseased units

Nature of observations	B. R. College—Bichpuri Farm, Field 'A'	B. R. College—Bichpuri Farm, Field 'B'
1. Total disease intensity score per unit	265.900 ±19.100	322.650 ±11.490
2. Average number of plants per unit (thickness of the stand)	3.650 ±0.010	4.440 ±0.050
3. Average disease intensity score per plant	72.931 ±1.680	73.550 ±2.060

Data on the disease intensity score per unit and the thickness of the stand in the unit are utilized to give the average disease intensity score per plant (percentage disease intensity) for that diseased unit. The low standard errors indicate that the disease intensity is almost the same in both the fields under observation.

Table II

CROP-LOSS

Observations on yield from healthy and diseased units and loss

Nature of observations	B. R. College—Bichpuri Farm, Field 'A'	B. R. College—Bichpuri Farm, Field 'B'
1. Mean yield of grains (gms.) for healthy unit	17.413 ±0.130	18.068 ±0.880
2. Mean yield of grains (gms.) for diseased unit	4.943 ±0.420	4.740 ±0.509
3. Mean yield-loss (gms.) per unit	12.489** ±0.470	13.471** ±0.846

**Significant at 1% level.

The loss in yield is highly significant showing that there is a definite relationship between disease intensity and loss in yield in both fields A and B. The data further indicate that yields from healthy units respectively of fields A and B are almost the same and so is with the losses from diseased unit of the two fields.

Table III

DISEASE INTENSITY AND CROP-LOSS RELATIONSHIP

Correlation coefficients ('r' values) and regression coefficients ('b' values) between percentage disease intensity and loss in yield

B. R. College—Bichpuri Farm, Agra.	Correlation coefficient ('r' value)	Regression coefficient ('b' value)
Field 'A'	0.929**	0.261
Field 'B'	0.403**	0.166

**Significant at 1% level.

The correlation coefficients ('r' values) are significant at 1% level in both the fields, but the value differs considerably, being 0.929 in field A and 0.403 in field B. Regression coefficients ('b' values) could be calculated as 'r' values are significant. The regression coefficients indicate that for each one per cent increase in the disease intensity, losses in the yield in the two fields amount to 0.261 gms. and 0.166 gms. respectively. In order to find out whether the two 'r' values (0.929 and 0.403) differ significantly from each other, standard error of the difference between the two 'r' values is calculated according to Fisher's method (Fisher 1944, pp. 198) as shown in the following table :—

Table IV

SIGNIFICANCE OF DIFFERENCE BETWEEN THE TWO OBSERVED CORRELATION COEFFICIENTS

	'r' value	'z' value	n—3	Reciprocal
Field 'A'	0.929	1.6510	97	0.0103
Field 'B'	0.403	1.4272	97	0.0103
Difference	——	1.2238 ±0.1460	—	——

As the difference in 'r' values of the two fields A and B (1.2238) is more than twice the standard error (± 0.1460) it is significant. The significant relationship can also be made out from the scatter of the points in Graphs I & II, the higher the 'r' value the closer the scatter.

DISCUSSION

Chester (1950 p. 217) points out that "estimates of disease or losses were generally approximate without any measurements and are often not correct" and suggests that "unless a purely random method of sampling is employed, there is a tendency for a plant pathologist's disease loss estimates to be biased by a complex of several factors". The method adopted in the present studies, selecting a random unit, each of one yard length, gives a better idea of disease loss. This is in slight modification to Chester's individual method. The modification of the method is all the more better as it will give the idea of the mean of that unit and if there is any compensation due to deficient stand, that would also be accounted for and will give the average of the unit (Suneson 1946). Further the loss in yield is estimated from a comparison of the yield in healthy units giving an accurate estimation of losses (Pal 1936 and Vasudeva 1946).

The average disease intensity score per plant determined by this technique is 72.931 (±1.689) and 73.550 (±2.060) and the loss in yields 12.489 gms. (±0.470) and 13·471 gms. (±0.846) in the two fields respectively, indicating that the loss in yield is significant, and that there is a definite relationship between disease intensity and loss in yield. The correlation coefficients ('r' values) significant at 1% level are 0·929 and 0.403 in the two fields under observation. Regression coefficients ('b' values) indicate that for 1% increase in the disease intensity losses in the yields in the two fields amount to 0.261 gm. and 0.166 gm. respectively. The difference in the two 'r' values (1.2238) is significant as it is more than twice the standard error (±0.1460) indicating a significant difference in the two 'r' values (0.929 & 0.403), which is also seen in the scatter of the graphs. The different behaviour of field A and B may be due to different soil conditions of the fields which were more than 100 yards apart and have been under different cultural practices before this cultivation. Although significant figures have been obtained for both the fields still definite conclusions can only be drawn from the experiments extended to larger area and for several years. In as much as the technique is concerned it appears to be satisfactory in elucidating the disease intensity and losses.

SUMMARY

A preliminary investigation has been made on wilt of gram caused by *Fusarium orthoceras* App. and Wr. var. *ciceri* with reference to disease intensity and crop-loss in the two fields in Bichpuri Farm, Agra. A suitable technique was developed to measure the disease intensity by reducing the visual observation of the symptoms to a quantitative index depending upon the period and amount of wilting. The data were analysed statistically and correlation coefficients were determined for both the fields under observation. In order to find out if the two 'r' values of the two fields differ significantly from each other standard error of the difference between the two 'r' values is calculated and the graph between the percentage disease intensity and loss in yield for both fields has been plotted.

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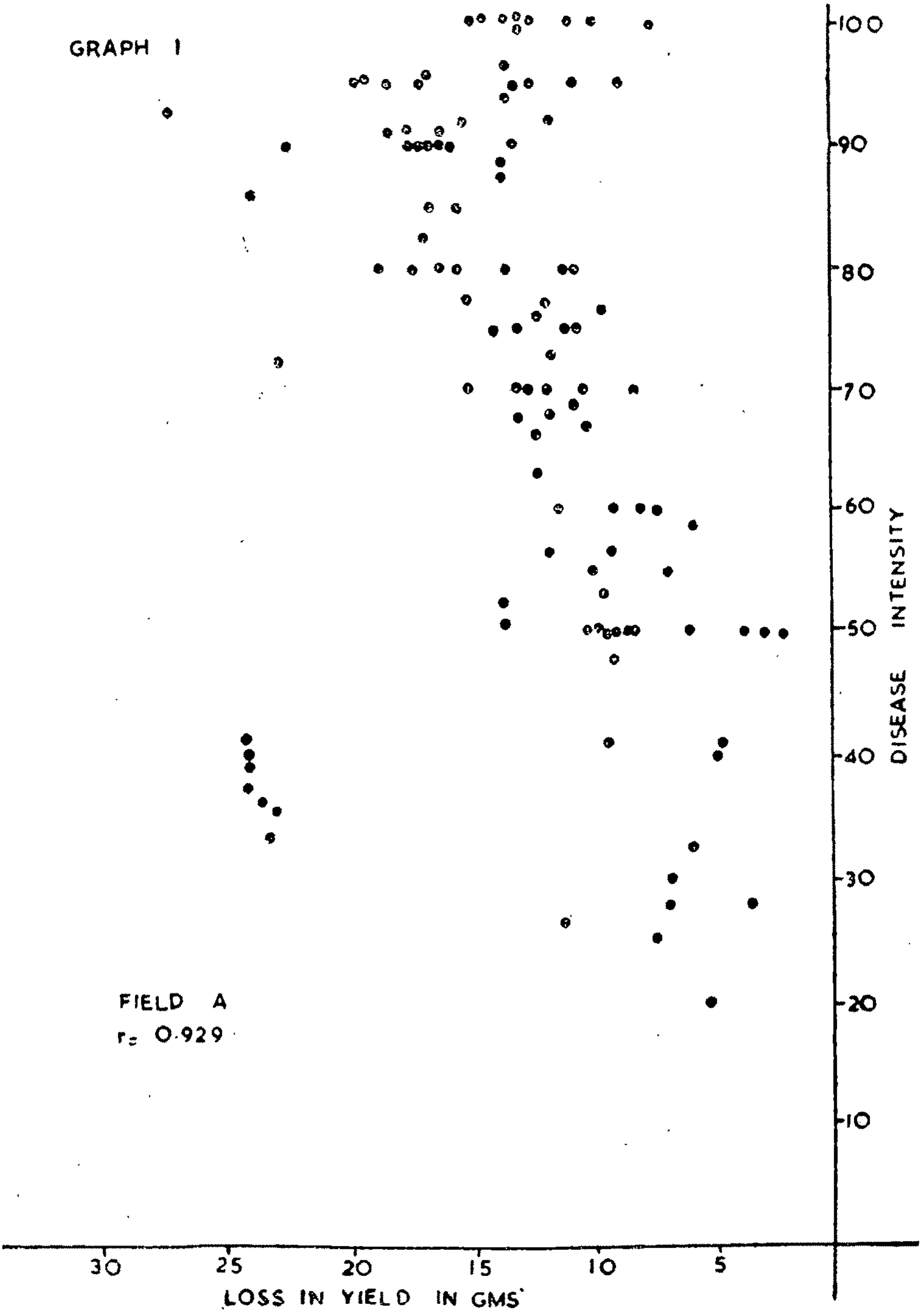
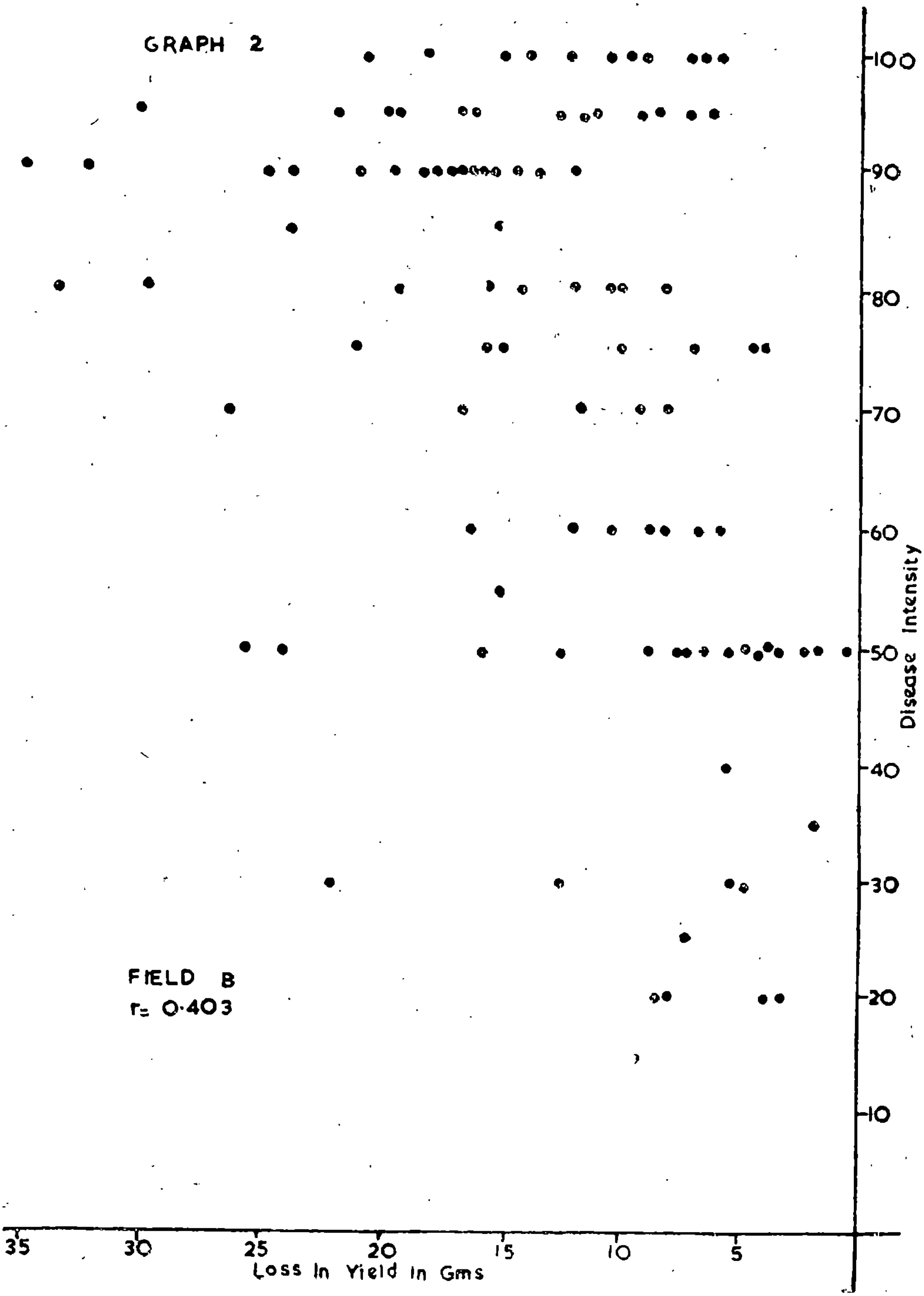

GRAPH I
FIELD A
r = 0·929
100
90
80
70
60
50
40
30
20
10
DISEASE INTENSITY
30
25
20
15
10
5
LOSS IN YIELD IN GMS


GRAPH 2
FIELD B
r= 0·403
Disease Intensity
100
90
80
70
60
50
40
30
20
10
35
30
25
20
15
10
5
Loss in Yield in Gms

STUDIES ON COMPARATIVE UTILIZATION OF AVAILABLE MOISTURE BY SAL (SHOREA ROBUSTA) AND SOME ASSOCIATED WEED SPECIES

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It is a common place knowledge that all plants require water for their existence and development. Most of the absorbed water is lost by transpiration. Opinion regarding the significance of transpiration have ranged all the way from it being benificial to "a necessary evil" (Curtis, 1926). Lutz (1957) has rightly remarked that "a fruitful field of research lies in what may be termed as physiological ecology or ecological physiology. As we pass beyond the descriptive phase of forest ecology we encounter increasingly complex problems, the solutions of which seems to be rooted in the physiological behaviour of the various stages of growth".

The problem of natural regeneration of sal is one of such complex problems. The management of *Shorea robusta* forests in the U.P. is being seriously affected by the lack of established reproduction in most of the important sal tracts of U. P. especially in the submontane and tarai divisions.

The failure of sal seedlings to survive in many forests has been studied by many workers such as Hole (1919), Champion (1933), Seth (1951) Griffith and Gupta (1947) and Puri (1951), and they have attributed many causes for the failure of regeneration. One of the reasons advanced is that the availability and utilization of water by sal seedlings, during the critical period of growth, is the limiting factor. The general survival is also regulated by adequacy of soil-moisture all the year round. Water logging caused during rains and drought during summer are equally inimical. The earlier investigations, therefore, suggest a quantitative study of water intake, transpiration and moisture competition in the floristic complex containing the sal seedlings throughout the year for assessing the role of moisture in the survival of seedlings and its correlation with the relative ease with which regeneration can be secured.

METHOD OF THE LAYOUT OF THE EXPERIMENT

Transpiration studies on one year old seedling of sal (*Shorea robusta*), *Mallotus philippensis*, *Clerodendrum infortunatum* and *Dioscorea belophylla* were carried out in the unweeded plots maintained for the root competition experiments. The rate of transpiration by sal seedlings in the weeded plots were also recorded for purpose of comparison. One seedling of each species under investigation was marked in a one meter square area in one of the unweeded subplots. Two small funnels of plastic, having equal size and circumference were used for confining the transpiring surface. Calcium chloride was used as the absorbing agent. Small rods of Calcium chloride mixed with asbestos were tied with waxed thread, dried in the oven and kept in a dessicator. One Calcium chloride rod was kept in each funnel, the thread passing through the stem. This assembly was stored in the dessicator until required.

Small rubber rings, of the size of the circumference were placed on both sides of the leaf for making it air tight. Springs were used for keeping the funnels securely in place. The whole of the openings of the funnel stems were blocked by vaseline to make the whole system air tight. The experiment was conducted as far as possible on the same particular day of every month (15th day) for about eight hours. The difference in weight of Calcium chloride before and after the experiment corresponds to the amount of water tranpired by the particular surface and absorbed by the chemical. Total amount of water transpired by both the leaf surfaces in eight hours was determined and on this basis the rate of transpiration per hour per unit area was calculated. In order to work out the water economy in the unweeded plots the number of plants of various species per square meter and their leaf area were noted to determine the proportion of water transpired by each species. For this the data was collected for five months from August, 1957 to December, 1957.

Results :

Table I

Rate of transpiration gms. per hour per sq. cm.

Months	1 *Shorea robusta* in weeded plots.	2 *Shorea robusta* in unweeded Plots.	Ratio 1/2	3 *Clerodendrum infortunatum.*	4 *Mallotus philippensis.*	5 *Dioscorea belophylla*	Ratio $\frac{2}{3+4+5}$
January 1957	0.0060	0.0047	1.276	0.0044	0.0068	0.0040	0.309
February ,,	0.0073	0.0063	1.158	0.0055	0.0070	0.0053	0.353
March ,,	0.0089	0.0074	1.067	0.0065	0.0080	0.0062	0.357
April ,,	0.0090	0.0072	1.250	0.0070	0.0096	0.0063	0.328
May ,,	0.0099	0.0081	1.222	0.0072	0.0097	—	0.479
June ,,	0.0079	0.0063	1.253	0.0060	0.0073	0.0056	0.333
July ,,	0.0042	0.0033	1.272	0.0046	0.0037	0.0042	0.264
August ,,	0.0023	0.0020	1.160	0.0031	0.0037	0.0036	0.192
September,,	0.0070	0.0050	1.400	0.0043	0.0062	0.0064	0.295
October ,,	0.0074	0.0062	1.193	0.0070	0.0080	0.0054	0.303
November ,,	0.0059	0.0047	1.255	0.0051	0.0055	0.0063	0.278
December ,,	0.0058	0.0043	1.348	0.0046	0.0054	0.0058	0.272

The table of rates of transpiration per hour per square centimeter area indicates that the rate is the highest for sal seedlings in the weeded plots in six months, *viz.*, February, March, May, June, September and December, the highest value occurring in the month of May. From January onwards the rate of transpiration of this species in weeded plots gradually increases till the maximum is reached in the month of May, then it gradually falls in June and from June to August it falls down considerably, the minimum occurring in the most humid month of August. There is considerable increase in September. From October it again registers decrement, the second minimum falling in December. In the month of January and April the rate for sal in weeded plots is lower only to *Mallotus philippensis*, in the month of July lower only to *Clerodendrum infortunatum* and in the month of August lower than *Mallotus philippensis*, *Clerodendrum infortunatum* and *Dioscorea belophylla*. In the month of October *Mallottus philippensis* and in November *Dioscorea belophylla* had the higher rate of transpiration than sal in weeded plots. In December the rate was equal with that for *Dioscorea belophylla*.

On the other hand Sal (*Shorea robusta*) in unweeded plots, *i.e.*, in association with its natural competitors in the ground flora, shows a lower rate of transpiration than *Mallotus philippensis*, but higher than *Clerodendrum infortunatum* and *Dioscorea belophylla* from January to June. As expected it also transpire less moisture than the plants in weeded plots. It has the lowest rate of transpiration of all the species in the complex in July, August, November and December. In September the rate is only higher than *Dioscorea belophylla*. It is evident from the data that the closest competitor of sal for soil moisture is *Mallotus philippensis* & *Clerodendrum infortunatum*. *Clerodendrum infortunatum* and *Dioscorea belophylla* show almost the same pattern of transpiration. From January to July and in October *Dioscorea belophylla* had a slightly lower rate than *Clerodendrum infortunatum* but in August, September, November and December the reverse was the case. In November and December *Dioscorea belophylla* had the highest rate of transpiration of all the species, equalled in December by sal in weeded plots.

Proportional leaf area for these species were recorded from August to December (Table 3). The data is inadequate for a broad generalisation but the trend indicates that *Mallotus philippensis* had the largest amount of leaf area in all the months. It is followed by *Shorea robusta* in weeded plots, which has, however, a considerably lower leaf area than *Mallotus philippensis*. In case of *Mallotus philippensis* and sal the proportional leaf area gradually falls from August to December, whereas it gradually increases in the case of other two species, *Clerodendrum infortunatum* and *Dioscorea belophylla*.

Table 2

Total leaf area (Sq. Cms.) per square meter

Months	In weeded plots	In Unweeded Plots			
	Shorea robusta	*Shorea robusta*	*Mallotus philippensis*	*Clerodendrum infortunatum*	*Dioscorea belophylla*
August 1957	53.75	55.42	72.12	48.22	34.97
September ,,	54.34	57.90	74.52	50.75	37.57
October ,,	56.72	59.02	76.63	53.02	40.25
November ,,	59.58	60.91	79.42	57.75	45.00
December ,,	61.48	62.47	81.24	63.05	48.75

Table 3

Percentage leaf area in unweeded plots

Months	*Shorea robusta*	*Mallotus philippensis*	*Clerodendrum infortunatum*	*Dioscorea belophylla*
August 1957	26.29	34.22	22.88	16.59
September ,,	26.23	33.76	22.99	17.02
October ,,	25.78	33.42	23.22	17.58
November ,,	25.06	32.67	23.76	18.51
December ,,	24.45	31.79	24.68	19.09

Table 4

Percentage of water transpired per square meter

Months	In weeded plots	In unweeded plots			
	Shorea robusta	*Shorea robusta*	*Mallotus philippensis*	*Clerodendrum infortunatum*	*Dioscorea belophylla*
August 1957	18.92	16.46	41.33	23.28	18.92
September ,,	32.73	23.38	39.44	17.54	19.64
October ,,	28.08	23.54	38.88	23.54	14.03
November ,,	27.63	22.02	33.57	22.67	21.72
December ,,	28.14	20.88	34.14	23.05	21.93

Considering the fraction of water transpired by each species, out of a given quantity available from the soil, *Mallotus philippensis* transpired the greatest amount, considerably more than sal, *Dioscorea belophylla* transpired the smallest amount except in August and September when the amount exceeded that for sal and for *Clerodendrum infortunatum* respectively. The amount of water transpired by Sal (*Shorea robusta*) was the lowest in August. The amount of water transpired by *Mallotus philippensis* gradually decrease whereas in other cases there is a net increase from August to December, except in case of *Dioscorea belophylla.*

With increase in temperature the rate of transpiration gradually increases from January onwards till the maximum is reached in May for all the species investigated. With the onset of rains at the end of June the rate of transpiration considerably falls down, the lowest rate being recorded in August for all species when the rain fall, humidity and soil moisture values were also the highest.

From August to September there is a steep fall in rainfall, humidity and soil moisture. Temperature although it falls, does so but slightly, correspondingly the rate of transpiration of all species increases considerably. From October till December there was a gradual decrease in temperature and correspondingly the rate of transpiration in this period also gradually decreased.

Table 5

Soil and atmospheric conditions during the experiment

Months	Mean for theday			Mean for the month
	% Soil moisture content (0-50 Cms.)	Humidity%	Temperature °F	Rainfall inches
January 1957	21.82	74	54.5	0.5
February ,,	19.30	73	64.0	0.47
March ,,	18.41	71	71.8	0.97
April ,,	18.24	46	72.4	1.37
May ,,	16.62	44	81.7	2.79
June ,,	16.91	49	88.0	3.69
July ,,	28.28	83	86.5	14.43
August ,,	28.25	88	82.6	19.63
September ,,	22.72	75	74.0	3.95
October ,,	18.56	73	68.9	1.66
November ,,	20.18	74	66.4	1.08
December ,,	21.00	78	55.5	4.07

Therefore, transpiration is inversely correlated with rainfall, humidity and soil water contents, as when these factors are high the ratio of transpiration is low and vice versa. Temperature on the other hand shows, in general, a direct correlation with transpiration, although its role is masked at some points by the influence exerted by the other factors. This masking may also be due to interaction of other atmospheric factors such as wind velocity, light intensity, etc.

DISCUSSION

As the rate of transpiration of sal in weeded plots is the highest recorded in most of the months, and as the rate of transpiration of sal in unweeded plots is always lower than that of Sal in weeded plots, it can be stated that there is a definite competition for moisture in the natural ground flora and sal is deprived of some needed moisture by the associated weed species, *Mallotus philippensis*, *Clerodendrum infortunatum* and *Dioscorea belophylla.* If this competition is removed by carrying out weedings, sal gets an opportunity to make a greater use of the soil water supply, as reflected in its higher rate of transpiration under these conditions and presumbly puts on more active growth. This is actually confirmed by the analysis of height of the plants recorded in weeded and unweeded plots which was also carried out in the other experiment.

The present study reveals clearly that *Mallotus phillippensis* whose rate of transpiration is comparable to that of sal (*Shorea robusta*) in the weeded plots, is the chief competitor for soil water. This fact, combined with the observation that *Mallotus philippensis* has the greatest amount of proportional leaf area in the natural floristic complex, considerably more than sal, shows the intense competition exerted by this species, as it arrogates to itself the greater proportion of water available in the soil and transpires the largest percentage. So far as *Dioscorea belophylla* is concerned it shows a low rate of transpiration except in a few months immediately after the rains, when the supply of stored ground moisture is large, and as at the same time its proportional leaf area is smaller, the total percentage of water transpired by this species is the lowest. It is, therefore, clear that this species is not a serious competitor for available moisture . *Clerodendrum infortunatum* also had a lower rate of transpiration than sal upto June and its proportional leaf area was also smaller. But in the later half of the study, that is from July onwards, the rate of transpiration and percentage of water transpired by *Clerodendrum infortunatum* was slightly in excess of that of sal. Thus, this species is not an acute competitor for soil water till June or so, but later on the competition exerted by it gradually increases, although not to an extent comparable with *Mallotus philippensis.*

If we consider that a given amount of soil moisture is present at a given time than the depletion due to transpiration can be compared on the basis of figurss given in table 2 and 3. If in the case of the unweeded plots the depletion is assumed to amount to 100 units per day, then out of this only 16.46 units are transpired by sal and the rest by the weed species. In the same period only 18.9 units are lost from the weeded plots and are fully utilised by sal alone. Of course the different rates of surface evaporation from weeded and unweeded plots, the possibly higher rate of transpiration of the larger tree in the weeded plots and other factors will necessitate a revision of these figures such that the desparity does not remain so pronounced nevertheless there will be a substantial residual difference in the amounts of moisture lost through transpiration from the weeded and the unweeded plots. This shows to what a great extent soil moisture would be conserved by weeding, as against this sal plants in the unweeded plots may be said to suffer from water starvation in a comparative sense. The enormous effects of weeding, not only in diverting the essential moisture to the economic sal plants, but also in conserving the available supplies of soil moisture for greater utilisation over a longer periods, are thus clearly brought out by this analysis.

CONCLUSIONS

It is, therefore, evident that *Mallotus philippensis* in particular and Clerodendrum infortunatum and other weeds in general deprives sal of the available moisture and also cause accelerated depletion of soil moisture, which might otherwise have been adequate for a longer period. Therefore, cutting of weeds specially of *Mallotus philippensis* bushes in the early summer before rains, *i.e.*, in April-May when the period of greatest competition for soil water is beginning and which is also the period of maximum growth of sal seedlings, and again in winter, *i.e.*, in November and December when there is renewed competition, although of lesser magnitude for soil water, will help in the better development of sal seedlings.

SUMMARY

Adverse moisture balance is supposed to be one of the many causes of the failure of the natural regeneration of sal (*Shorea robusta*). In order to assess the comparative utilisation of and competition for available moisture, studies on transpiration of sal seedlings in weeded and unweeded plots were carried out along with the commonest weed species. The study revealed clearly that the sal seedlings are deprived of soil moisture to a significant extent by the weed species. This is mainly due to the competition, for available water, exerted by the presence of other species in abundance. *Mallotus philippensis* is probably the chief competitor for soil water, its rate of transpiration being comparable to that of sal.

This study serves to confirm the desirability of cutting weeds specially *Mallotus philippensis* bushes in the early summer before rains (April-May) when the period of greatest competition for soil water begins and which is

also the period of maximum growth of sal seedlings, and again in October and November when there is renewed competition for soil water.

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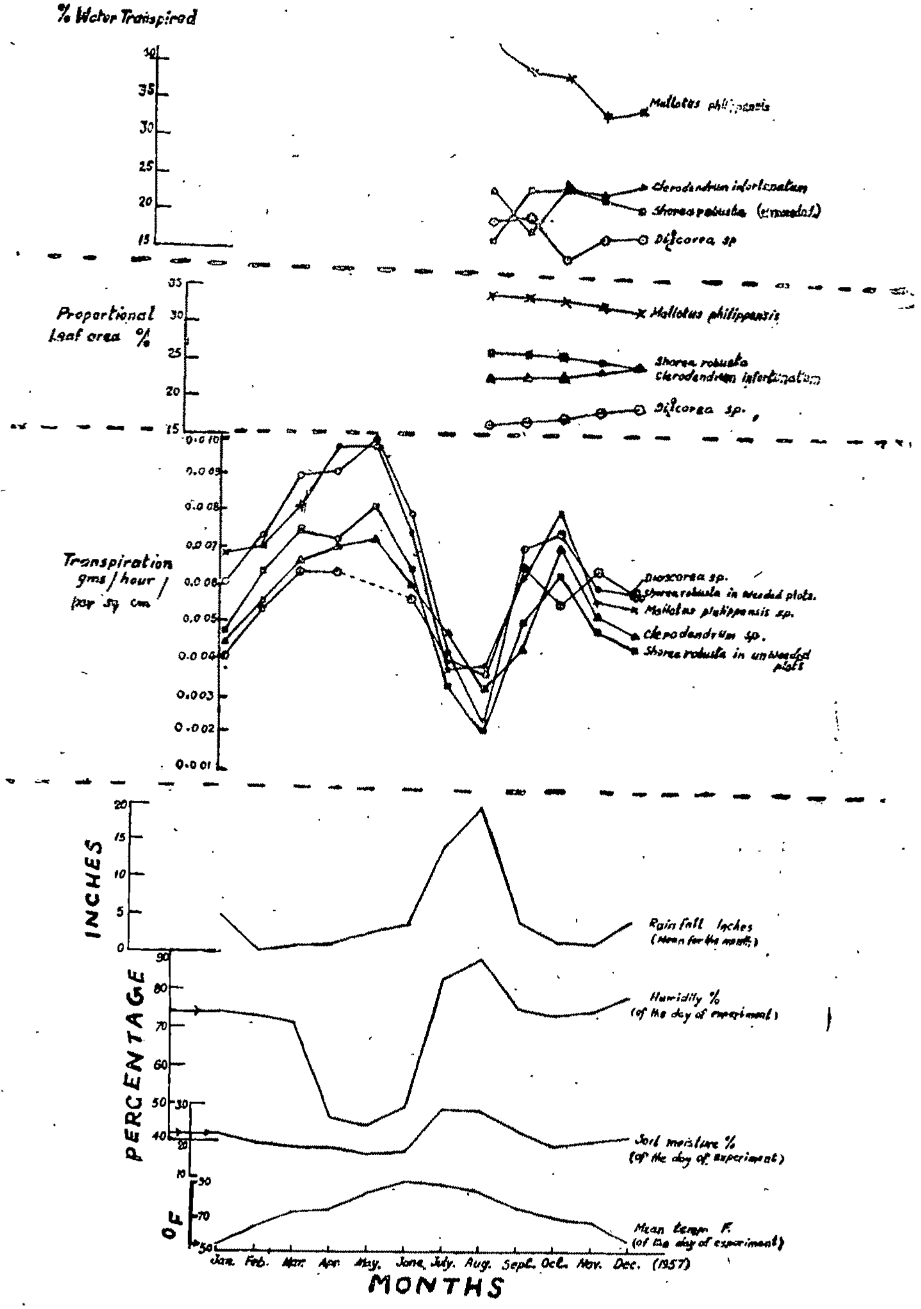
% Water Transpired
40
35
30
25
20
15
Mallotus philippensis
Clerodendrum infortunatum
Shorea robusta (unweeded)
Dioscorea sp
Proportional Leaf area %
35
30
25
20
15
Mallotus philippensis
Shorea robusta
Clerodendrum infortunatum
Dioscorea sp.
Transpiration gms / hour / per sq. cm
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
Dioscorea sp.
Shorea robusta in weeded plots.
Mallotus philippensis sp.
Clerodendrum sp.
Shorea robusta in unweeded plots
INCHES
20
15
10
5
0
Rain fall Inches (Mean for the month)
PERCENTAGE
90
80
70
60
50
40
Humidity % (of the day of experiment)
30
20
10
Soil moisture % (of the day of experiment)
°F
90
70
50
Mean temp. F. (of the day of experiment)
Jan. Feb. Mar. Apr. May. June July. Aug. Sept. Oct. Nov. Dec. (1957)
MONTHS

STRUCTURE AND ABNORMALITIES OF THE FEMALE GENITALIA IN INDIAN BUFFALO. *Bos (Bubalus) bubalis* L.

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One of the most important problems facing the dairy industry in the tropical countries has been to get a suitable animal which, in addition to yield good quality of milk, should be able to withstand the rigours of the tract. It must be hardy, resistant to diseases, and should be able to subsist on coarse and scanty fodder. The Indian buffalo, *Bos (Bubalus) bnbalis* L., possesses these qualities and is admirably suited for tropical dairying. It occupies an important position among Indian livestock, and contributes significantly to the economy of Indian cultivator. Besides being the chief source of milk, it also produces meat and excellent quality-hide for varied use. Above all, its ability to withstand tropical conditions, to convert coarse roughages more efficiently into richer milk, to breed and produce more uniformly than cows are some of the important characteristics that make it worthy of consideration. Indian buffaloes produce more than 50% of the country's milk and are highly domesticated and docile. An average animal yields from 3,500 lb. to 4,500 lb. of milk per lactation, while exceptionally good animals are known to have produced 11,000 lb. of milk within a year—Kothawala (24). With regard to quality of milk, no domestic animal approaches it in fat content which on an average varies from 6% to 9%—Mudaliar(32) with a maximum of 13%—Hafez (15). Nutritionally also it is superior to cow's milk by way of Vitamin A and protein content.

From the breeding point of view, nothing is more important than the regular fertility of this animal. Troubles, which strike at the fundamental operation of breeding this animal, are responsible for huge economic losses, the exact figures for which are not available but estimated to be quite high. Late maturity, fewer or no calvings, frequent abortions, long dry periods, silent breeding, and inability to breed are quite common among female buffaloes which consequently fail to produce their entire potential.

Man has long known about these troubles but very little was understood about them till recently. With the development of endocrinology and newer experimental techniques, the problem has received a closer attention all over the world and a good volume of information is now available with regard to cow, sow and sheep. An attempt has been made to extend such a work to this class of animal to increase their reproductive potential and help in artificial insemination.

REVIEW OF LITERATURE

A detailed description of the female genitalia in buffalo and malformations associated with it are inadequate and superficial. However, parallel information is available for cows (3, 5 13, 20, 25, 34, 35, 39, 47, & 48), sows (46) and sheep (4, 44). The only attempts with regard to buffaloes are the following :—

The signs of oestrus and the behaviour of both sexes at mating have been described by Ocompo (33), who states that the symptoms are more marked in Philippine buffalo than the Indian buffalo. He attributes the absence of thick vaginal discharge during heat to the frequent urination of the oestrus female. In general, the symptoms seem to be more intense than in cattle. The duration of oestrus is 1 to 1½ days with a maximum of 4 days as reported by him. He also described the symptoms of pregnancy, approaching parturition, behaviour during post-partum and changes in the live-weight and body measurements of pregnant buffaloes.

Kaleff (22), while studying ovulation in buffaloes, states that the conception follows ovulation in healthy animals with fertile mating and the latter does not depend upon the age, yield of milk or exercise. The facts about the cycle length, duration of heat, gestation period, age at first conception, interval between calvings and the time of post-partum heat for different breeding centres have been studied by a number of workers, namely Dave (9), Kaleff (21), Kangaratnan (23), Ocompo (33), Levine (26), Markus (28), Maymone (29), Regab and Asker (37), and workers in Federated Malaya States (12) whose observations have been reviewed and summarised by Hafez (15). Work on similar lines involving ovarian activity, cornual pregnancy, sex-ratio, and transmigration of ovum in Indian buffaloes has been reported by Damodaran (6&7). The fact, that the environment affects the length of gestation, has been studied by Ghanem *et al* (14) in 224 gestations of 126 buffaloes during the period of 15 years.

Polding and Lall (36) have given a descriptive account of the comparative genital anatomy of buffalo and cow. They state that in buffalo the recent corpora lutea are veined with haemorrhagic protrusion while the regressing corpora lutea are not veined and are white in color. They have also stressed that during the cycle the luteal substance was never yellow but the luteal cavities were common. A few pathological cases have been reported by them.

Recently Rao and Murari (38) while handling the aspects of reproduction in buffaloes have reviewed oestrous cycle and gestation, distribution of calvings during the year, birth-weights, interval between calvings and calving and first heat along with their own observations for Indian buffaloes. Dave (10) drew his attention to the total number of calves per female and concludes that as many as 14 to 15 calves can be had during the lifetime of a female.

Endocrinology of buffalo also has interested some of the workers. Roy *et al* (40) estimated the ascorbic acid content of buffalo ovaries at various stages of oestrus and indicated that it is concerned with the synthesis of the hormones by the corpora. They also indicate that the normal corpora had higher ascorbic acid content than the per istant ones. Mohmoud and Hafez (31), on the other hand, have performed ovariotomies to study the urinary excretion of ovarian hormones. Deane and Nayudu (11), while studying the effects of endocrinal activity on body temperature and vaginal and cervical secretions, concluded that there exists a definite relationship between the phase of the oestrus, vaginal and anal temperatures and the ability of the mucus to form fern pattern on drying.

The aspects of infertility and sterility have received a very little attention. Polding and Lall (36), examined 185 buffaloes for genital abnormalities and indicated the incidence of cervicitis, metritis, cysts and tumors of ovaries and genital tract. Mohan (30), while studying the possibility of Vibrio-foetus infection, tested vaginal mucus of 7 buffaloes, experiencing various degrees of breeding troubles, and indicated that only one showed positive reaction.

Hafez (17), while concluding his paper on foetal atrophy based on 50 gravid and 24 nongravid genitalia, indicates four types of foetal atrophy associated with thinning of uterine walls and loss of fluid pressure at different stages of pregnancy. He holds that breeding at first postpartum oestrus is associated with oestrous irregularities in buffalo. He also associates foetal atrophy with small corpus luteum and abnormally short and untightly constricted cervix indicating the possibility of atmospheric air entering the uterus and leading to subsequent bacterial infection. It may also be possible that the smaller corpora lutea may be deficient in progesterone production which might be insufficient to maintain pregnancy. He also feels that there may be the possibility of some disturbed hormonal balance (between gonadic, gonadotrophic or placental), or the sex cells (ova or sperms) may be defective at the time of fertilization or there may be some undesirable tubal or uterine environment involved. He further holds the unregressed corpus luteum as an explanation for the suppression of the oestrus after successful pregnancy.

He reports that two, three, or even more services are needed per conception and about 17% of the animals, having apparently normal cycles, do not conceive at all. In some cases the abnormally long and short cycles are also reported. He also reports that 30% of the animals have one and 11% have two silent heats, a number of animals have anoestrous condition and quite a few abort. He also records cystic ovaries, cystic corpora and hypoplasia of the ovaries. He further holds that the genetic make-up of the endocrine system of the buffalo cow is responsible for the absence of nymphomania in this animal.

Recently, Sane, Kaikini, and Koranne (41) have placed two cases of vaginal abscesses on record which blocked the entire vaginae and rendered them sterile after a couple of calvings. Sengar and Malik (43) also attempted to study the normal genitalia and various malformations associated with it in the female buffalo.

For working out the present project a total of 1,000 cases were given antemortem and postmortem examinations in the city slaughter house of Agra, North India. These animals were non-descript and uneconomical either due to sterility, low fertility or old age and came from the adjoining tracts No reliable information on their breeding efficiency could be had due to lack of proper records. It is, therefore, suspected that these probably did not represent the average of the population in a reliable sense. Nevertheless, it is hoped that even this population would be indicative of the trend.

The animals included in the study were selected at random and the observations were spread all the year round such that 400 (40%) cases were examined during winter, 200 (20%) during rainy season and 400 (40%) during summer. Their age, approximated by teeth and horns and general health condition, recorded in terms of arbitrary grades, are shown in table 1. The entire reproductive tracts were first carefully examined in situ and then taken out and dissected and—or preserved if necessary. Materials for the histological studies were fixed in Bouin's fluid and the sections were stained with suitable stains.

Table I

Showing the age and health groups of the population Studied

Age in years			*Health*		
Class	*Frequency*	*%*	*Class*	*Frequency*	*%*
Below 5	10	1.0	very good	16	1.6
5 & 6	44	4.4	good	140	14·0
7 & 8	100	10·0	fair	360	36.0
9 & 10	160	16.0	poor	420	42.0
11 & 12	266	26.6	very poor	64	6.4
13 & 14	300	30.0			
Above 14	50	5.0			
Unrecorded	70	7.0			
Total	1000	100.0		1000	100.0

ANATOMY OF THE NORMAL GENITALIA

Realizing the fact that complications and malformations related to breeding troubles can only be understood and appreciated with a proper understanding of the normal structure (Fig. 1), 50 apparently normal genitalia, proportionately drawn from each of the above groups, were closely examined and the various organs measured. Their average dimensions and how they compare with those of the cow reported by Perkins et al (34) are shown in Table II.

The Vulva on the sides is bounded by a pair of thick highly distensible and sparsely haired lips enclosing the clitoris at their ventral commissure (Fig. 2). It continues as vestibule and meets the vagina with a well marked vestibulo-vaginal sphincter in majority of the cases. The suburethral diverticulum, lying below the opening of the urethra on the floor, is large enough to accommodate the index finger, but the openings of the Gartner's ducts have normally disappeared. Lacerated remnants of hymen are noted in some cases at the region of vestibulo-vaginal constriction. The vestibular glands lying on the floor are also large. The length of the opening indicates the vertical distance between the two commissures while the width is indicative of the broadest region of both lips together. The depth of the vestibule was measured as the shortest distance between the hymenal line and the inner margins of the lips.

The Vagina is a voluminous musculo-membraneous tube lying flattened in a horizontal fashion and forming the deep fornix around the vaginal os. The anterior part of it has highly wrinkled inner lining. In some cases a peculiar sphincter was noted just behind the vaginal os. Histologically it has the usual three layers and is elastic. The size varied considerably with regard to age and the state of the animal. The normal vaginal debris contains large epithelial cells, a number of leucocytes and many bacilli. The length of the vagina was measured from the ventral fornix up to the hymenal sphincter while the flat diameter of the tube was considered for the width.

The Cervix is highly thick walled with lamellated lining and much restricted spiral lumen due to annular constrictions. The main folds extend in craniocaudal direction projecting into the uterus as internal os and into the vagina as external or vaginal os (Fig. 3); and are rich in goblet mucus secreting cells. The vaginal os has circular and regular lips in heifers, but in the parturated females, it gets lacerated and irregular in outline. The tone of the cervix differs considerably depending upon the reproductive phase of the animal. Cervical plugs were noted in almost all healthy pregnancies. Histologically, it is lined by columnar epithelium which gradually changes to sqamous at the vaginal os. The length of the cervix was measured by feeling the external and internal os, while the width was taken at the thickest region. Diameter of the vaginal os and its projection at the dorsal fornix were measured and the number of longitudinal folds and transverse constrictions were also recorded.

The Uterus has a short compact median body and spirally twisted paired horns which show a tendency of untwisting with age. The tubouterine junction, although not abrupt, is quite distinct and lies at the tip of the horn. Internally the body is divided by a well developed septum leaving a very small corpus communicating the two horns (Fig. 3). In most cases the folds of the inner os are large enough to meet the dividing septum anteriorly and practically obliterating the corpus and separating the two horns completely from each other. This might have been the reason for the statement that there is no uterine body in the Egyptian buffalo by Hafez (17). Caruncles, about 50 in each of the horns, are irregularly distributed. The identity of the two horns is almost completely lost during advanced pregnancies.

Histologically, the body and the horns are alike and consist of the usual three layers. The endometrium is highly rich in glands while the myometrium has large numbers of spiral vessels (Fig. 4). During pregnancy, the caruncles develop alveoli, get differentiated and enlarged to form cotyledons by the inpushings of the anastomosing chorionic villi of the foetus (Fig. 5). The length of the body was taken from the region of the internal os upto the point of the apparent separation of the two horns while the broadest region was considered for the width. The length of the horns is indicative of their greater curvature from the point of apparent separation upto the tubouterine junction, while the width represents the thickest region of the same. The number of caruncles for the horns and body were counted together.

The Oviducts are slender, zigzag tubes along the mesosalpinx pouch over the ovary. Histologically, it also consists of the inner mucosa, the middle muscularis and the outer serosa. The mucosa is thrown out into anastomosing folds or plicae to almost completely fill the lumen of the tube (Fig. 6). No cilia could be demonstrated, probably due to thick sections. Isthmus has thicker wall than the ampulla. The length of the tubes was measured by running a thread along their course from the point of tubouterine junction upto the base of the funnel, while the width of the isthemic and ampullery portions was taken separately at about their midpoints. The infundibular funnels was measured flat for the diameter.

The Ovaries are apparently equal in size (the right being slightly larger) and may be spherical, oval or elongated in shape. There is relatively more difficulty in locating the ovaries per rectum in buffaloes than in cows due to their more tightly secured condition in the broad ligament. Graafian follicles and corpora lutea were noted on both the ovaries, although the right ovary seemed to share a relatively larger number of them, exhibiting more oogenetic function. 56.9% G.F. and 54.3% C. L. met during the course of investigation were found on the right ovary, which very well compare with 52.6 % ovulations from right ovary observed by Damodaran (7) and 75 % by Hafez (19). There seemed to be some indication that in younger females the right ovary was slightly larger and more active than the left one, but in the older ones (after 12 to 13 years) the situation was found to be reversedas the left ovary was found to be more active and larger.

Histologically treated specimens showed both developing follicles and corpora lutea. Whenever the C.L. was present, it occupied the major portion of the ovary (Fig. 7); and was seated deep enough for the easy removal in many of the cases. Their size and shape also varied considerably.

A set of 50 apparently normal ovaries were measured. Length is indicative of their craniocaudal elongation, width indicates broadest region from side to side, while the thickness denotes the height from the hilum to the apex. For weighing, they were cut along the mesovarium.

Table II

Average size of the reproductive organs in Buffalo and Cow

Organ	*Buffalo* (Malik *et al*)			*Cow* (Perkins *et al*)		
	No. measured	Mean (cm.)	Standard deviation	No. measured	Mean (cm.)	Standard deviation
Vulva						
Length of lips	50	11.76 ±0.21	1.47	...	...	...
Width of lips	,,	5.26 ±0.12	0.88	...	...	...
Length of vestibule	,,	7.08 ±0.20	1.39	91	9.65	1.24
Vagina						
Length	,,	19.21 ±0.33	2.40	95	17.58	1.84
Width	,,	5.48 ±0.17	1.23	...	...	...
Cervix						
Length	,,	5.95 ±0.20	1.39	100	7.99	1.38
Width	,,	3.58 ±0.14	0.97	100	3.25	0.83
Diameter of vaginal os	,,	2.30 ±0.07	0.57	...	...	...
Depth of fornix	,,	1.24 ±0.06	0.40	...	...	...
No. of longitudinal folds	,,	7.68 ±0.36	2.49	...	...	...
No. of transverse constrictions	,,	2.77 ±0.13	0.90	93	3.22	0.70
Uterine Body						
Length	,,	5.47 ±0.20	1.49	...	...	...
Width	,,	4.17 ±0.12	0.86	...	...	...
Size of corpus	,,	1.20 ±0.06	0.43	...	...	...

Table II (*Contd.*)

Average size of the reproductive organs in Buffalo and cow.

Organ	Buffalo (Malik *et al*)				Cow (Perkins *et al*)		
	No. measured	Mean (cm)		Standard deviation	No. measured	Mean (cm)	Standard deviation
Left Horn							
Length	50	26.44	±1.00	7.08	100	39.00	6.82
Width	,,	3.05	±0.10	0.75	100	2.28	0.40
No. of caruncles	,,	48.10	±1.03	7.23	...	...	...
Right Horn							
Length	,,	26.58	±1.07	7.60	100	39.56	7.42
Width	,,	3.15	±0.11	0.79	100	2.40	0.57
No. of caruncles	,,	49.00	±1.08	7.67	...	...	...
Left Oviduct							
Length	,,	19.12	±0.33	2.35	98	20.68	2.30
Width of Isthmus	,,	0.26	±0.01	0.05	98	0.26	0.04
Width of Ampulla	,,	0.56	±0.02	0.14			
Flat diameter of funnel	,,	5.99	±0.20	1.39	...	...	...
Right Oviduct							
Length	,,	19.31	±0.34	2.41	95	20.71	2.40
Width of Isthmus	,,	0.26	±0.01	0.05	95	0.26	0.04
Width of Ampulla	,,	0.56	±0.02	0.14			
Flat diameter of funnel	,,	5.93	±0.18	1.30	...	...	...
Left Ovary							
Length	,,	2.03	±0.05	0.34	99	3.44	0.54
Width	,,	1.45	±0.04	0.27	99	2.25	0.45
Thickness	,,	1.25	±0.04	0.28	99	1.62	0.38
Weight in gm.	,,	2.50	±0.15	0.98	...	...	...
Right Ovary							
Length	,,	2.08	±0.06	0.39	97	3.60	0.58
Width	,,	1.58	±0.05	0.35	97	2.40	0.53
Thickness	,,	1.33	±0.48	0.34	97	1.75	0.39
Weight in gm.	,,	2.72	±0.17	1.16	...	...	...

Recently Damodaran (8) has come out with some observations on the measurements of female genitalia on the basis of 15 animals between 2½ to 3½ years, which very closely agree with our data. The differences between the right and the left organs were found to be insignificant. The measurements compare fairly well with those reported for cows except for ovaries and horns of the uterus which are smaller than those of the cows.

PREGNANCY

Although the reproductive pattern of buffalo is almost similar to that of the cow, with regard to the length of the oestrous cycle, the duration of oestrus, the time before post-partum oestrus and the morphology of both pregnant and non-pregnant genitalia, yet there is a considerable difference in their gestation period which is 317 days (Hafez (15) as compared to 280 days of the cow (Van Demark) (45). Rao and Murari (38), from a study of 302 pregnancies involving 191 animals, have concluded 310.4 days for the Indian buffalo.

A total of 108 (10.8%) pregnancies were recorded during the course of invetsigation which had 50% female, 31.5% male, and 18.4% unidentified foetuses as follows:

Horn	*Females*		*Males*		*Unsexed*		*Total*	
	No.	%	No.	%	No.	%	No.	%
Right	44	40.7	10	9.3	18	16.6	72	66.6
Left	10	9.3	24	22.2	2	1.8	36	33.3
Total	54	50.0	34	31.5	20	18.4	108	99.9

The pregnancy C.L. was invariably found on the ovary corresponding to the gravid horn and in no case the intrauterine migration of ovum or twinning was noted. The pregnancy C.L. apparently seemed to be slightly larger and more deeply seated than the non-pregnancy C.L., while the size of the graafian follicles was just the reverse on the two kinds of ovaries. Similar results have also been concluded by Hafez (19), on the basis of 50 pregnancies. A case of twinning has also been reported by Afsar (1).

These observations do not agree with those of Damodaran (7) who reports 50.3% pregnancies in the right horn (25% females & 26.1 %males) and 49.7% in the left horn (26.5% females & 22.3% males) and also a case of intrauterine migration (6). The sex-ratio among the 88 sexed foetuses was found to be 62.9 (males per 100 females), whereas Damodaran (7) on the basis of 188 sexed cases holds it to be 93.7.

There seems to be some indication that more females develop in the right horn than males and vice versa. This seems to contradict the old statement of Seligson (42) that the right ovary produces male producing ova and the left ovary produces female producing ova.

Looking at the general trend of the ovarian activity and the pregnancies on the two sides, it appears that for some reason or the other, there is more embryonal or foetal mortality in the left horn than in the right one. As there seem to develop more males in the left horn they die more and thus seem to account for the wide variation in the noted sex-ratio.

ABNORMALITIES AND MALFORMATIONS OF THE GENITALIA

A number of abnormalities and a variety of malformations were recorded during the course of investigation. These were either congenital or acquired and reduced the fertility or rendered the animal sterile, depending upon the degree of severity. Their incidence and how they compare with those of cows (Perkins *et al*) (34) have been shown in Table III.

VULVA

The Vulva, being the exposed organ of the genitalia, is more susceptible to injury and infection.

The Vulvitis was the most common defect met with. It was characterized by the reddened vestibule, oedematous swelling of the lips and mucoid discharge adhering to the vulvar tufts. Small nodules and bruising of the peritoneum were also noted in some cases. These apparently did not affect fertility. But in some cases (Fig. 20) vulva along with vagina underwent severe constriction which must have barred copulation. A total of 258 (25.8%) cases of vulvitis were recorded.

The Persistent Hymen : A total of 8 (0.8%) cases of persistent hymen were met with. In only one case it was imperforate and the imprisoned utero-vaginal secretions were noted, while in rest of the cases it was perforated or existed only as a remnant band of tissue thick enough to be easily broken. The specimen (Fig. 8) is from an animal which must have experienced considerable difficulty during copulation. None of these apparently seemed to have calved at all.

The Persistent Wolffian Ducts were found to occur as Gartner's ducts only in 2 (0.2%) cases. These were found as a pair of sacs opening on either side of the meatus urinarius through large openings (Fig. 9). They could accommodate glass rod to a considerable distance.

The persistent hymen and the Wolffian ducts are known to be inherited in cattle and seem to depend upon genetic assortment (Pfau) (35).

VAGINA

The Vagina, being the organ of copulation and passage way for the young, is likely to suffer from mechanical injury, subsequent infection and related troubles.

The Vaginitis in majority of the cases coexisted with vulvitis. It may have been sequel to metritis or vulvitis or even both. As many as 243 (24.3%) cases of inflamed vaginae were noted while executing the project. It is presumed that these must have arisen due to some sort of mechanical injury either during copulation or parturition or any other sort of violence.

The Urovagina was found only in one (0.1%) case (Fig. 10). Antemortem examination per rectum gave the impression of unusually swollen vagina. Mucopurulent discharge with characteristic smell was also noted. The post-mortem examination indicated that the vestibule, vagina and the urinary bladder were all incorporated into a peculiar mass to allow their identification difficult. On opening, the vagina was found to have developed a wide communication with the urinary bladder and both were full of pus. Other organs, although normal, were suggestive of the subnormal size. It is presumed that this condition must have arisen due to some violent activity of some sex perverted person or false entry of the penis.

The Double Vagina was also noted only in one (0.1%) case (Fig. 11). More than half of the anterior part of the vagina was divided into two distinct compartments by a vertical septum. It had left a confluent cavity in the posterior part of the vagina and just behind the vaginal os. All other organs were apparently normal and the animal had the symptoms of having calved several times. It could not be spotted out by antemortem examination.

CERVIX

The cervix is the most easily recognisable part of the genital tract and acts as an important barrier against bacterial invasion. A total of 227 (22.7%) cervical abnormalities of various types were found as follows :

The Cervicitis suspected by antemortem was confirmed by postmortem examinations in 99 (9.9%) cases, many of which co-existed with metritis. In some cases it was abnormally large (Fig. 12) with bloody mucoid secretions while the others were without much inflammation and secretion and the os had lost its folded appearance altogether (Fig. 13).

The Bent and Twisted Cervices were found to be quite common. Many of these could not be readily diagnosed per rectum. The degree of the bend varied considerably from simple 'S' shaped in some to spirally twisted in others (Fig. 14). Some of these could be straightened per rectum to put the inseminating nozzle through it, but in the majority of the cases even the best attempts failed to straighten it and introduce the pipette. Almost all these cases were apparently normal with the exception of unusually long and slender cervices. Some of these had also shown signs of having calved. It is presumed that under the influence of some sort of infection, the inner layers of the cervix tend to elongate and as the external coverings do not keep pace with it, it gets bent or twisted on itself. A total of 88 (8.8%) of such cervices were recorded during the course of investigation.

Closed Womb or imperforate condition of the os was recorded in 3 (0.3%) cases. These were apparently normal but had an exceptionally small os (Fig. 15) which was not perforated. The imperforate condition of the os was confirmed by a glass rod and then opening it. A sort of band was found to have developed within it, probably by the fusion of some of its folds.

Long Cervices were also recorded in 24 (2.4%) cases which were slender and very much elongated. On opening, these were found to have fewer longitudinal folds, while the number of transverse constrictions was five or even more in some cases.

Short Cervix was relatively uncommon and was met with in 11 (1.1%) cases only. Some of these were too small to be recognised per rectum (Fig. 16). In almost all such cases it had soft texture and was open and had led to the ascending infection of the uterus, the fallopian tubes and even the ovaries in the majority of the cases (Fig. 16). Some of these did not seem to have calved at all.

Double Cervices were found only in 2 (0.2%) cases (Fig. 17). Rectal palpation of these cervices gave an impression of the lateral fluid filled vesicles which were confirmed by postmortem examination. On opening, these vesicles were found to contain creamy viscous fluid; and the body of the cervix in this region was distinctly divided into two pieces of moderate length arranged in craniocaudal direction. This division was more complete in one than in the other. Other organs were apparently normal in both the cases. It is presumed that these animals must have presented difficulties in insemination and parturition as one of them had definite signs of having calved. How it must have been caused is not properly understood.

UTERUS

Uterus, the chief seat of pregnancy, is apt to be malformed in a variety of ways. A total of 182 (18.2%) uterine abnormalities were recorded while executing the project which were distributed as follows :—

The Metritis was one of the most common defects with the uterus. In most of the cases it coexisted with cervicitis and in a number of them led to a variety of consequences that follow it. Simple cases of metritis were noted in 113 (11.3%) cases. Some of these had highly inflamed condition of the uterus with or without the cervix being involved (Fig. 18), while others had only the local inflammation of varying degrees. The affected regions had highly thick walls while the mucous membrane showed red degenerations. Majority of these cases could easily be diagnosed per rectum during antemortem examination.

The Hydrometra, a condition somewhat similar to leucorrhoea in human beings, was also recorded in 27 (2.7%) cases. These apparently seemed to be normal containing varying amounts of watery, translucent fluids and with or without only slightly inflammed walls. On the other hand, in some of the cases the walls were very much reduced in thickness and had prominently projecting caruncles. This condition was more common with the old animals and could not always be rightly diagnosed per rectum; although loss of uterine tone was a fair indication in many cases.

The Haematometra and Pyometra. Cases totalling 34 (3.4%) could not be easily separated from each other, although the cases of pyometra were far more than that of haematometra. In almost all the cases, the uterus contained pus with or without blood which imparted to it a light brown to dark brown colour (Fig. 19). The enlarged and hard toned condition of the uterus could be easily diagnosed per rectum. In some cases, the cervix was relaxed allowing the contents to flow out through the vulva, while in others it was not open. The internal condition of the uterus in majority of the cases suggested that it must have occurred due to infection after parturition, retention of placenta, or abortion at advanced gestation. In some cases, the septum separating the two horns was also lost and the fallopian tubes, in many cases, had pyosalpinx. In some cases, the caruncles had a whitish band around them and apparently seemed to be unhealthy.

The Physometra was found only in 2 (0.2%) cases. Rectal palpation of these animals suggested an enlarged uterus, the size of about mid-pregnancy, but no foetus could be palpated. The vulvae and vaginae were conjested and subnormal in size. The postmortem examination reveale the balooned uterus, small cervix without vaginal os, and very small vagina. After passing a glass tube through the cervix, the uterus could be pressed to force the air out, a part of which was sucked back on releasing the pressure. An incision through the uterus revealed extremely thin walls with smooth lining and without any caruncle whatsoever (Fig. 20). The septum separating the two horns was also lost upto a considerable distance. Small amounts of brownish yellow fluids were also recovered from each of them. The fact, that both of these cases had calved, suggests that some time after parturition or abortion the uterus might have been infected with some gas producing organisms.

The Uterine Abscess was found only in one (0.1%) heifer of about 5 years and in good health (Fig. 21). The uterus along with the ovaries and broad ligament, was peculiarly disposed to form a pear-like structure in front of the cervix and could not be felt per rectum. On opening the animal, the whole mass was found reflected on itself ventrally to fuse with the bladder. It was with great difficulty that the tips of the horns, fallopian tubes, very small ovaries, and broad ligament could be separated from the common mass and the bladder. On opening the rounded mass, a big pool of pus was noted in the centre which might have developed in the septum between the two horns. The horns, shown in black, were greatly pushed on to the sides with a very narrow lumen and without any caruncles. Cervix, vagina and vulva were apparently normal. The structure on the top of the figure is the urinary bladder attached to the abscess. It might have been a case of uterine cancer.

The Mummified Foetuses were noted in 3 (0.3%) cases, two of which were septic (Fig. 22). These had well marked foetal site containing bones of the decaying foetus and a lot of pus filling every available space in the uterus. It is presumed that these animals might have been inseminated while they were pregnant with infected semen or instruments.

The aseptic mummy, on the other hand, was without any pus (Fig. 23). It is presumed that the foetus might have died due to some unknown cause and the foetal membranes got filled with the blood. Other organs were apparently normal and did not suggest any pathological condition.

The Uterus Unicornis was found with only a single (0.1%) case in which the left uterine horn along with fallopian tube, except the ovary, were completely missing. The corresponding organs on the right side, although structurally normal, had an abnormal disposition due to peritoneal infection. This animal was about 8 years old and must have calved before developing the infection as suggested by the udder development. Unfortunately this specimen could not be preserved.

The Blind Horn (Fig. 24) was also found only in one (0.1%) case which was diagnosed as normal per rectum. The body of the uterus and horns had a peculiar tone, while the fallopian tubes and ovaries were apparently normal. On opening the uterus, septa were found to divide the lumen of the horns into several compartments, which would have not allowed any passage for the descending ova or the ascending sperms and rendered it sterile. This condition may be attributed to some developmental freak of nature leading to incomplete canalization of the Mullerian ducts.

FALLOPIAN TUBES

The Fallopian Tubes that convey the ova from the site of production to the seat of development are also likely to be malformed or infected.

The Salpingitis and Pyosalpinx were the most common types of tubal diseases and were recorded in 139 (13.9%) cases. These were characterized by inflammation of the oviduct without pronounced distention with or without pus and were hard to be diagnosed per rectum. Tubes of one or both sides were affected, but the bilateral infection was more common. The pus filled condition of the tubes was more common during summer and generally co-existed with the pyometra, suggesting that the infection might have come from the uterus. These conditions are very important and seem to be responsible for a considerable loss in their breeding efficiency.

The Hydrosalpinx or fluid filled condition of the fallopian tubes was recorded in 25 (2.5%) cases which mainly came from the winter cases, suggesting a sort of seasonal condition. More frequently both sides were affected, but unilateral infections were not very uncommon. In majority of the cases, the margins of the funnel had fused with each other or with the broad ligament, with or without enclosing the ovary within it (Fig. 25). In some cases, various sorts of adhesions due to peritoneal infections were also noted (Fig. 26). Some of these cases could not be easily diagnosed easily per rectum.

A few of the affected tubes, histologically treated (Fig. 27), show great changes in the inner mucosa which is either completely or partially destroyed due to pressure atrophy.

OVARIES

Ovaries, the chief organs of reproduction, are apt tobe malformed in a variety of ways.

The Cystic Ovaries were come across in 18 (1.8%) cases which had varying numbers of cysts. In most cases, they were multiple (Fig. 28) and several times larger than the normal follicle (Fig. 29) with lot of watery fluid and extremely thin walls. A few of these also had haemorrhage in them. Several of these could be easily diagnosed per rectum to resemble the description of the nymphomaniac ovaries of cows, but the animals did not show any apparent nymphomaniac symptoms like coital mimicry or erratic behaviour as are known to exist among cows. In some cases, these cysts were quite thick walled and could not be ruptured even with a considerable amount of pressure applied to them (Fig. 30). Almost all these cases were unilateral and recovered from adult animals between 5 to 10 years of age with apparently otherwise normal genital tracts. It is, therefore, speculated that this condition is either due to defective physiology or undesirable inheritance.

The Tumours and Dermoid Cysts of ovaries were not uncommon with buffaloes as 23 (2.3%) cases were recorded. These could be easily recognised per rectum as unusually large, smooth, and hard structures. These were also unilateral in majority of the cases and, therefore, did not exclude the animal from breeding (Fig. 31). These tumours and cysts, when opened, were found to be unilocular and contained a variety of materials *e.g.*, a thick greasy cottony mass, yellowish siliacious material and solid debris with hard pieces, *etc.*, (Fig. 32). Some of these (Fig. 33) contained long matted hairs along with little or no pasty debris. These also seem to be due to defective development or defective inheritance.

The Ovarian Hypoplasia was of rare occurrence and could be met with only in 7 (0.7%) cases. The general conditions of the ovaries along with the rest of the genitalia suggested an infantile state irrespective of the age of the animal (Fig. 34). In almost all cases, this condition was bilateral and the animals did not breed at all. Such ovaries were very difficult to be located per rectum due to small size and did not show the evidence of oogenetic function when cut open. They resembled a solid tissue in cross section, *The Ovaritis and Periovaritis* were found in 47 (4.7%) cases, many of which escaped rectal palpation. These generally coexisted with salpingitis and peritonitis, which under the influence of some infection, led to various sorts of adhesions and malformations, either unilaterally or bilaterally. In some cases the ovary was encapsuled within a thin or thick sheet of tissue excluding the fimbria such that the ovulated ova could not be caught by the oviduct. Some of these had developed a sort of peri-oophorital bag around the ovary (Fig. 35) along with some exuded fluid in a similar manner. The ovaries, enclosed like this, did not apparently seem to be normal but did show the oogenetic activity as conceived by the presence of follicles in cross section.

The Atretic Follicles and Defective Corpora were identified only in 19 (1.9%) cases. Most of the atretic follicles co-existed with the persistent corpora lutea (Fig. 36) which were exceptionally large and apparently functional. In some cases the C. L. was not properly luteinised and showed some haemorrhage. Some of the apparently normal corpora, not included here, had cavities with or without fluid and were suggestive of their cystic condition.

BOARD LIGAMENT

A normal feature of the broad ligament is essential to maintain proper anatomical relations between the various parts for normal function. If malformed, it is likely to impair or completely limit reproduction, irrespective of the fact that other organs may be perfectly normal.

The Cysts of the Broad Ligament were quite common and a total of 36 (3.6%) cases were recorded. These varied a lot with regard to size, number and thickness of their wall. Sometimes they had developed along the fallopian tube and squeezed it to a non-functional state. Those, developing adjacent to fimbria (Fig. 37) disturb the anatomical relations between the funnel and the ovary due to their weight and may not allow the ovulated ova to enter into it. Some of the larger ones could be easily diagnosed per rectum as heavy structures tending to hang downwards. Both the thin and thick walled cysts contained watery fluid in them. In many cases they were too small to impair reproduction. In addition to broad ligament, small hydatids were also quite common on other parts as well.

The Peritonitis, leading to strangulated and ill disposed condition of the genitalia, was noted in 32 (3.2%) cases. It generally co-existed with metritis, salpingitis or perioophoritis and was apparently due to some sort of infection. In some cases the strangulation was so complicated that genitalia could not be laid out properly without cutting the broad ligament at several places (Fig. 38). In some of the apparently otherwise normal cases it must have interfered with the pregnancy by not allowing the uterus to extend fully well due to strong adhesions.

Table III

Incidence of Genital Abnormalities and Malformations in Buffalo and Cow.

Abnormality or Malformation	Frequency of occurrence as % in	
	Buffalo (Malik *et al*)	Cow (Perkins *et al*)
The Vulva :—		
Vulvitis	25.8	...
Hymens	0.8	6.3
Wolffian ducts	0.2	...
Cysts	...	3.4
Total	26.8	9.7
The Vagina :—		
Vaginitis	24.3	6.7
Granular vaginitis	...	28.3
Uro-vagina	0.1	0.2
Double vagina	0.1	...
Cysts	...	0.7
Total	24.5	35.9
The Cervix :—		
Cervicitis	9.9	8.9
Bent or twisted cervix	8.8	...
Closed wombs	0.3	...
Long cervix	2.4	...
Short cervix	1.1	...
Double cervix	0.2	0.3
Cysts	...	0.2
Total	22.7	9.4
The Uterus :—		
Metritis	11.3	5.3
Hydrometra	2.7	...
Haemato & Pyometra	3.4	...
Physometra	0.2	...
Uterine abscess	0.1	...
Mummified foetus	0.3	0.1
Decomposing foetus		
Uterus unicornis	0.1	0.2
Blind horn	0.1	0.2
Incomplete tracts	...	0.5
Invaginated uterus	...	0.1
Uterine adhesions	...	0.3
Total	18.2	6.7

Table III (*Contd.*)

Incidence of Genital Abnormalities and Malformations in Buffalo and Cow.

Abnormality or Malformation		Frequency of occurence as % in	
		Buffalo (Malik *et al*)	Cow (Perkins *et al*)
The Fallopian Tubes :—			
Salpingitis & Pyosalpinx		13.9	1.3
Hydrosalpinx		2.5	...
	Total	16.4	1.3
The Ovaries :—			
Cystic		1.8	2.2
Tumours & Dermoid cysts		2.3	...
Hypoplastic ovaries		0.7	...
Ovaritis, peri-ovaritis, & adhesions		4.7	4.8
Atretic follicles & defective C. L.		1.9	...
	Total	11.4	7.0
The Broad Ligament:—			
Cysts		3.6	...
Peritonitis		3.2	...
	Total	6.8	0.0

The organ-wise distribution of the abnormalities indicates that their incidence is maximum in the exposed and/or posterior-most organs and then it gradually decreases as we proceed anteriorly. This trend clearly suggests that some sort of infection is responsible for majority of these defects and is picked up at the posterior region of the genital tract. It may then gradually migrate anteriorly to other organs as well.

The frequency distribution of our findings does not compare favourably with those reported for cattle. Probably the data for cattle are based on American cows where utmost sanitary measures are adopted with regard to their breeding, feeding, handling and housing and consequently, allowing very little chances of infection whatsoever.

Among the various organs that are likely to become abnormal and limit or reduce reproduction, the fallopian tubes are most important because their defects can not be easily diagnosed. They are most probably the cause of undiagnosed sterility or lowered fertility in many cases.

SUMMARY

The importance of buffalo, *Bos* (*Bubalus*) *bubalis* L., for tropical dairying has been emphasised; and the paucity of information accompanied by a short review of scattered and superficial account on their breeding troubles has been pointed out. Observations on genitalia based on antemortem and postmortem examinations of 1000 females slaughtered at Agra, North India, have been presented, illustrated and described.

The normal structure of female genitalia based on 50 sets of measurements and how it compares with that of cow has been attempted. The paired organs on the two sides were found to differ only insignificantly with regard to their measurements but the ovarian activity was significantly different on the two sides.

A number of peculiar genital abnormalities and malformations as noted have been depicted and described. The frequency of their incidence has been recorded and compared with that reported for cow. Their over-all distribution with regard to various organs *e.g.*, vulva—26.8%, vagina—24.5%, cervix—22.7%, uterus—18.2%, fallopian tubes—16.4%, ovaries—11.4% and broad ligament—6.8%, suggests that the infection is picked up in the posterior region of the tract and it then migrates anteriorly to other organs. Some of these like physometra, hydrometra, uterine abscess, double vagina and cervix, bent and twisted cervix, dermoid cysts, Wolffian ducts, uterus unicornis, blind horn and adhesions of various sort have been reported for the first time for this class of animal. Among all, defective fallopian tubes seem to be quite common with Indian buffaloes to render them sterile or lowly fertile.

On the basis of these observations the following possibilities are suggested which may need confirmation by a still closer examination of a larger number of cases:

(1) In younger animals, the cervix is comparatively narrower and longer with a circular os, while in older ones it grows thicker and shorter with irregular and lacerated margins.

(2) The uterus is cylindrical and thick-walled with coiled horns in younger animals and becomes flattened, thin-walled, and with uncoiled horns in the older ones.

(3) The right ovary is larger in younger animals and has a predominating oogenetic function. But in the older ones the condition is reversed as the left ovary becomes larger and more active.

(4) Pregnancies in the newer animals are more in the right horn and more often carry a female calf, while the older ones more often carry a male calf in the left horn.

(5) Season seems to exercise an apparent influence upon some of the abnormalities. Hydrosalpinx and pyosalpinx indicated this trend.

(6) The incidence of pyosalpinx and cystic corpora seems to be quite high among buffaloes and is apparently an important factor in determining their reproductive efficiency.

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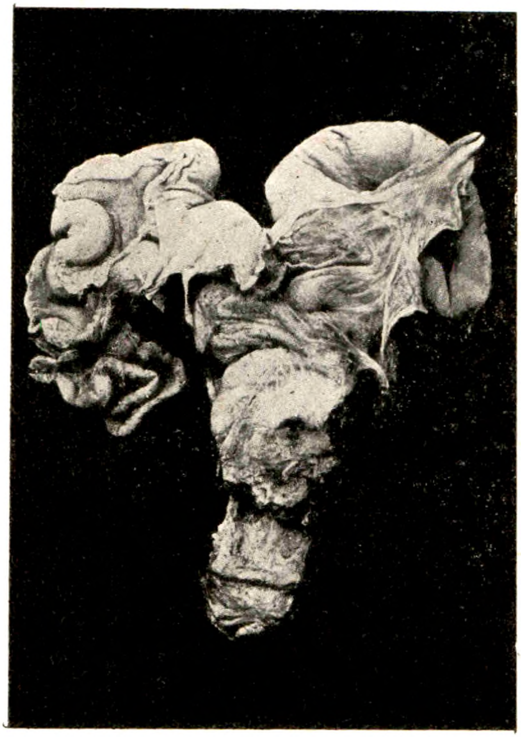


Fig. 38—Genitalia showing the infection of the peritoneum leading to severe peritonitis.

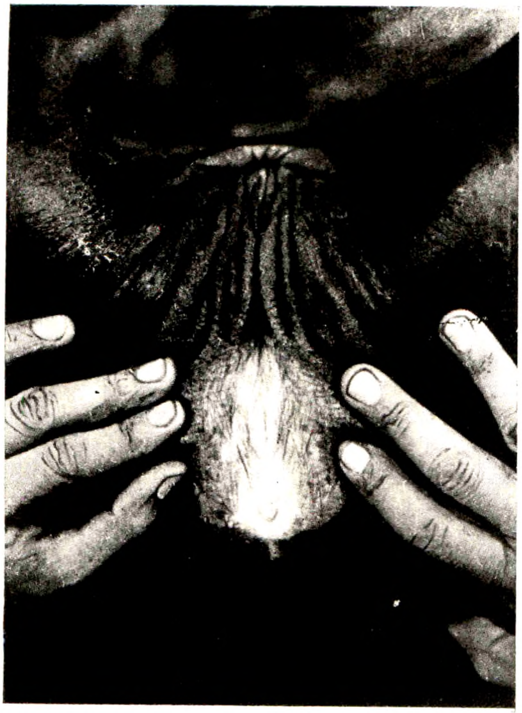


Fig. 2—Vulva, stretched to show the clitoris and the vulval tuft.

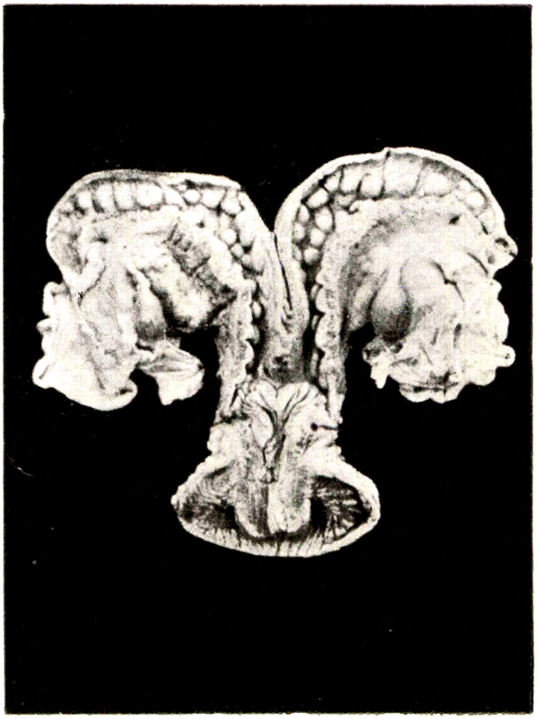


Fig. 3—Cervix and uterus exposed to show the cervical folds, small uterine corpus and caruncles.

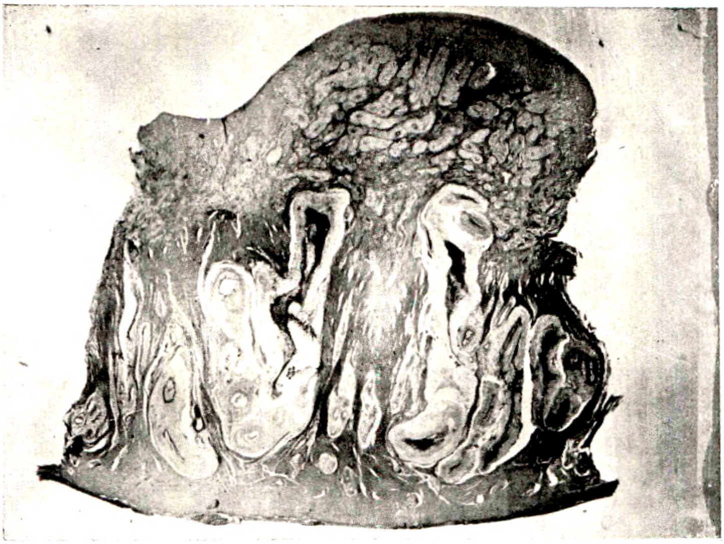


Fig. 4—T. S. of the uterine wall passing through a caruncle showing endometrium with uterine glands and myometrium with spiral vessels and elastic tissues.

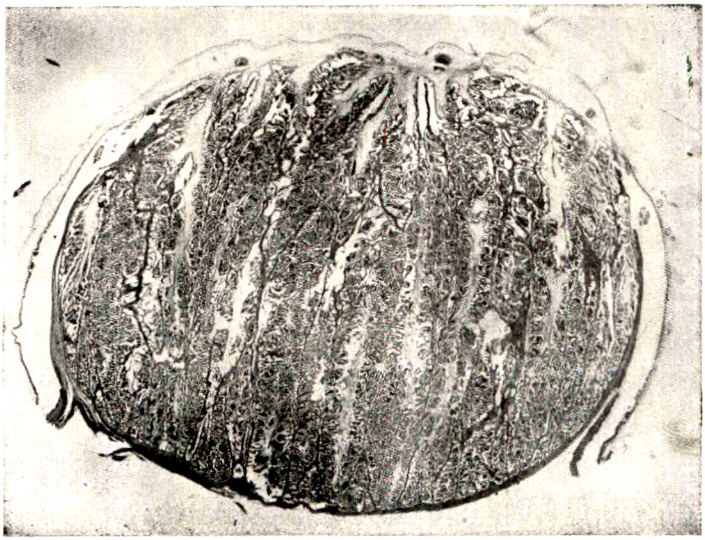


Fig. 5—T. S. of a cotyledon of late pregnancy, showing the inpushings of the anastomosing chorionic villi into the uterine alveoli.

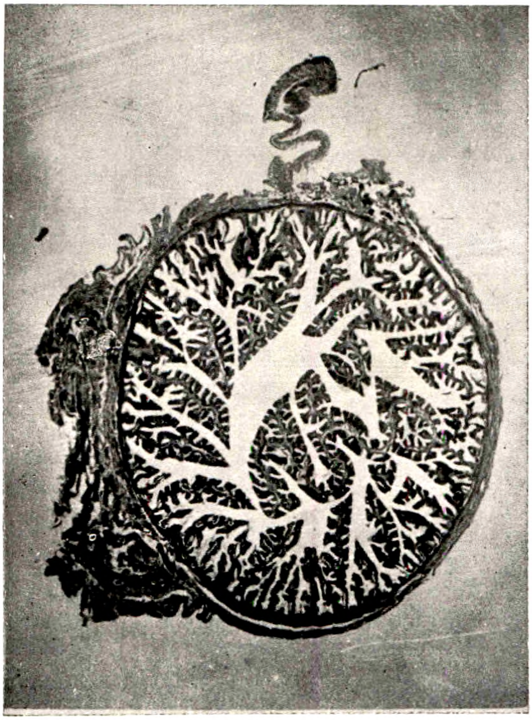


Fig. 6—T. S. of the fallopian tube showing the anastomosing plicae almost completely filling the lumen.

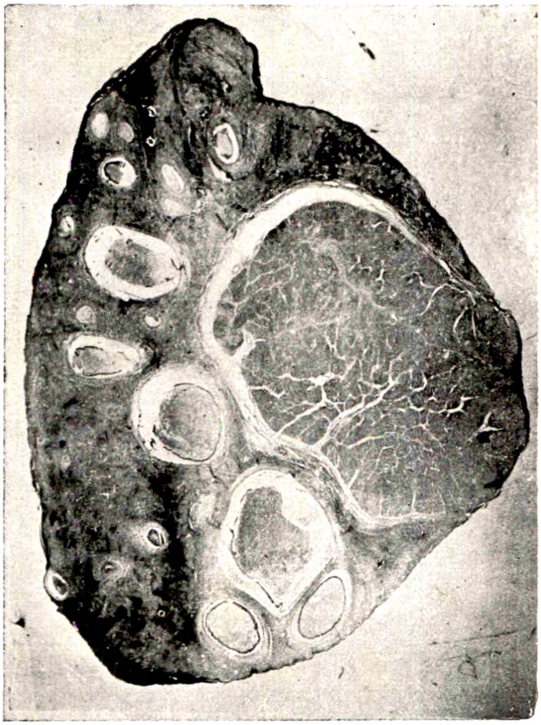


Fig. 7—T. S. of the ovary passing through the follicles and the C. L.

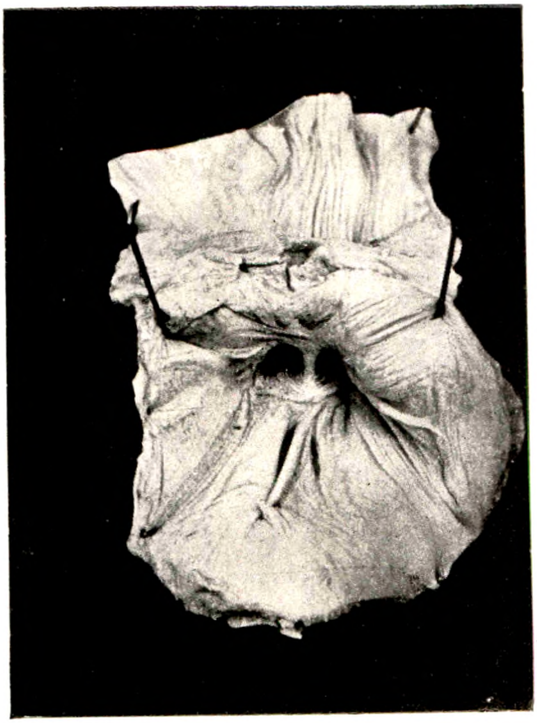


Fig. 8—Vestibule showing the remnant of the persistent hymen at the vestibulo-vaginal sphincter.

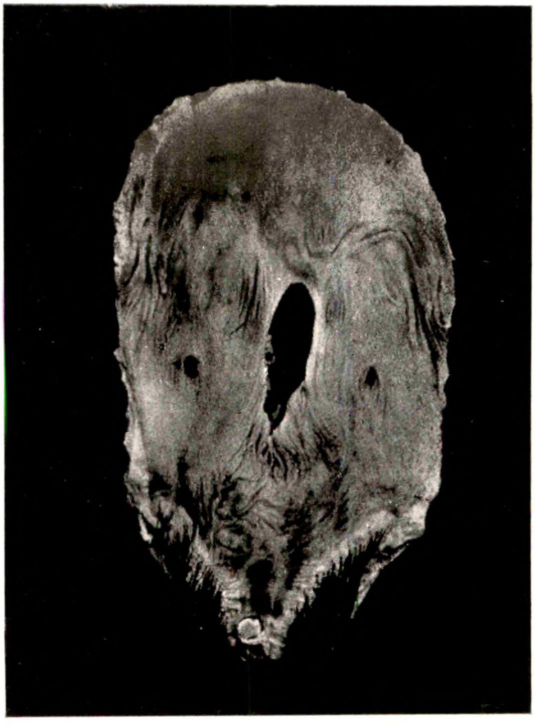


Fig. 9—Vestibule, showing the persistent Wolffian ducts on either side of the urethral opening.

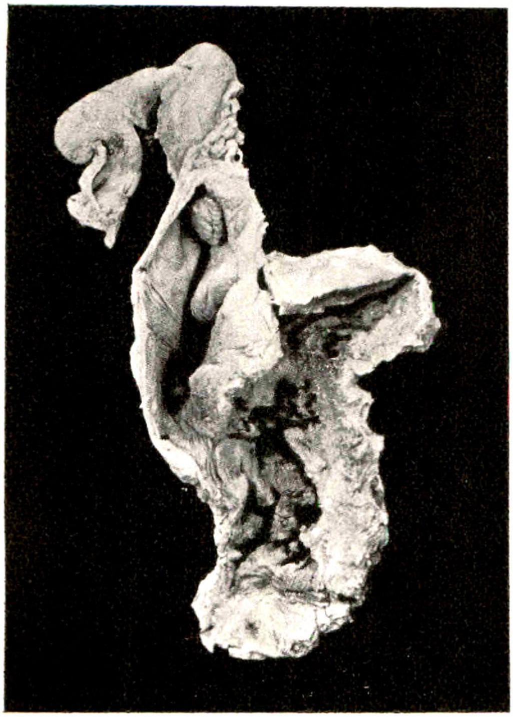
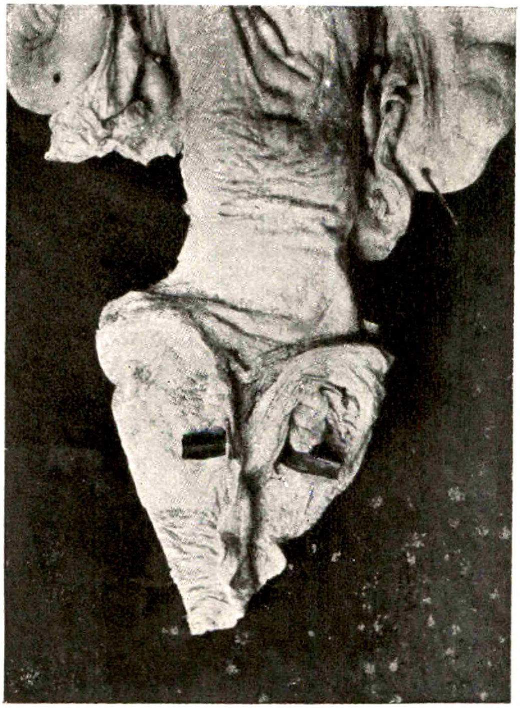


Fig. 10—Uro-vagina, showing a wide communication between the vagina and the urinary bladder.

Fig. 11—Double vagina, showing the septum dividing the entire length of the vagina.



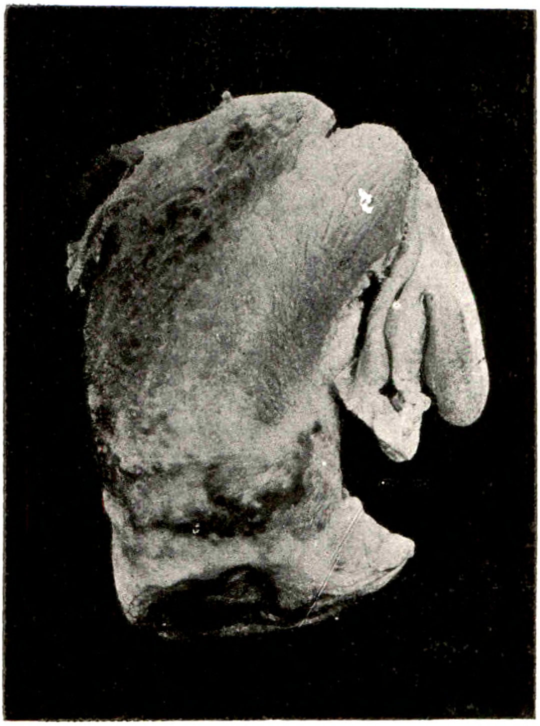


Fig. 12

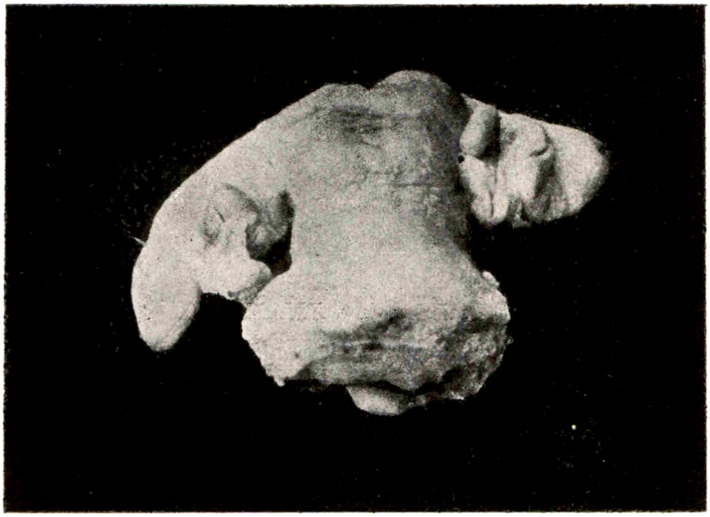


Fig. 13

Fig. 12 & 13—Cervicitis, showing the inflamed condition of the cervices.

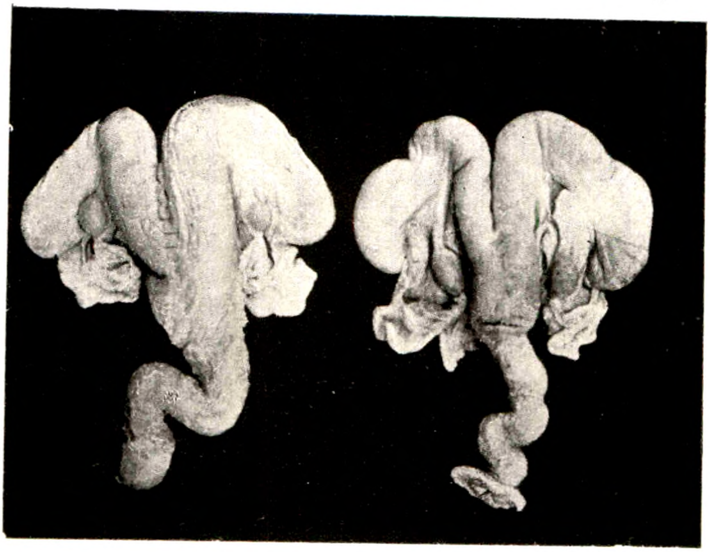


Fig. 14—Bent and twisted cervices that were hard to be straightened for artificial insemination.

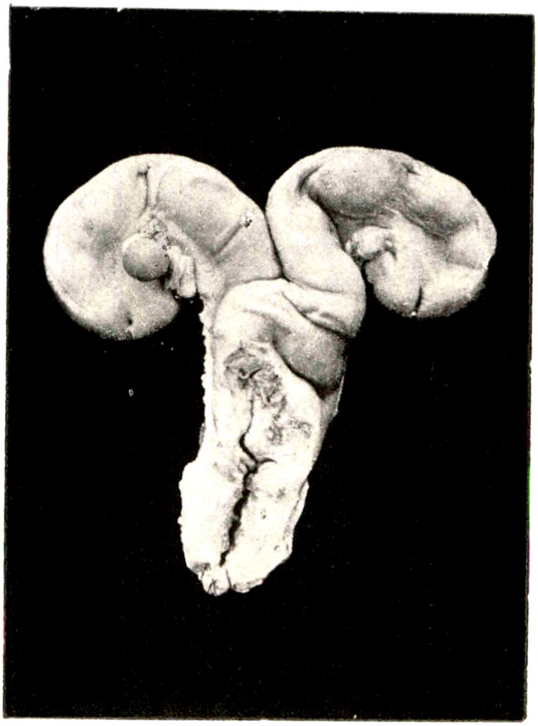


Fig. 15—Micro-os, showing the imperforate condition of the os.

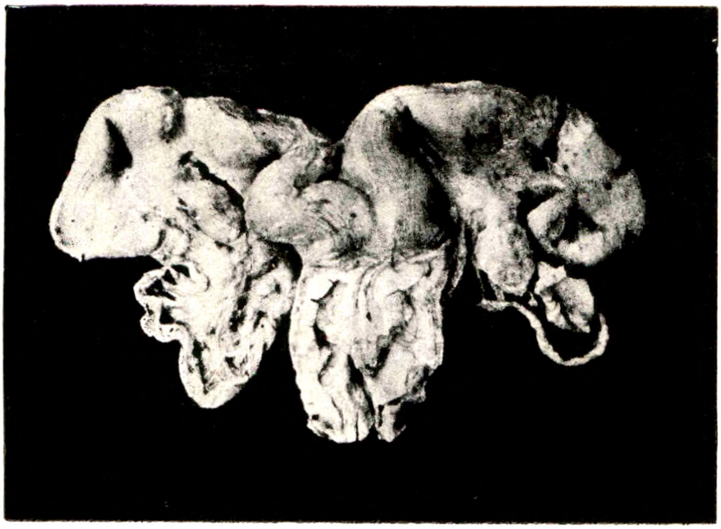


Fig. 16—Short cervix, showing its untightly closed condition.

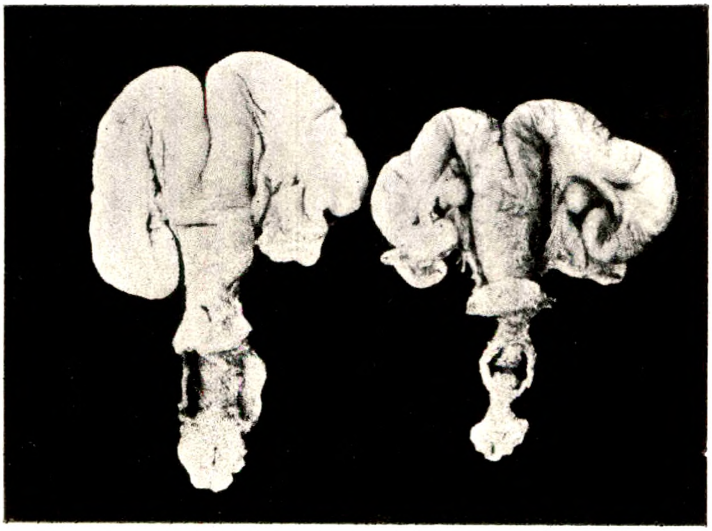


Fig. 17—Double cervices, showing their peculiar disposition in cranio-caudal direction.

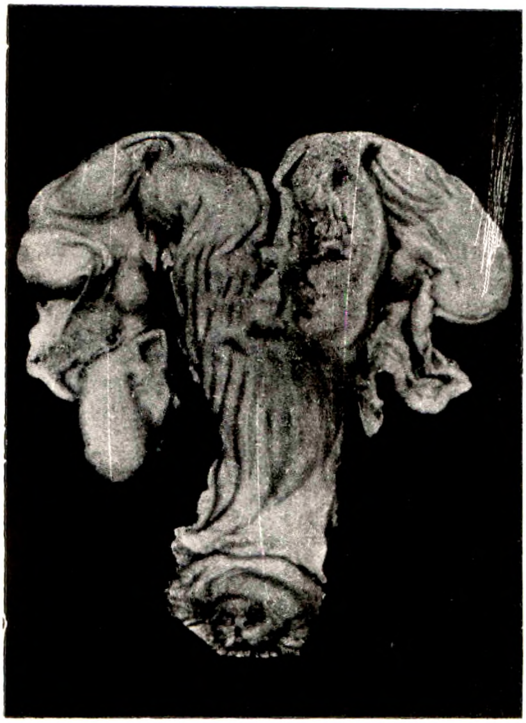


Fig. 18—Metritis, showing the exceptionally thick inflammed uterine walls. A hydatid of the broad ligament is also seen on the left side.

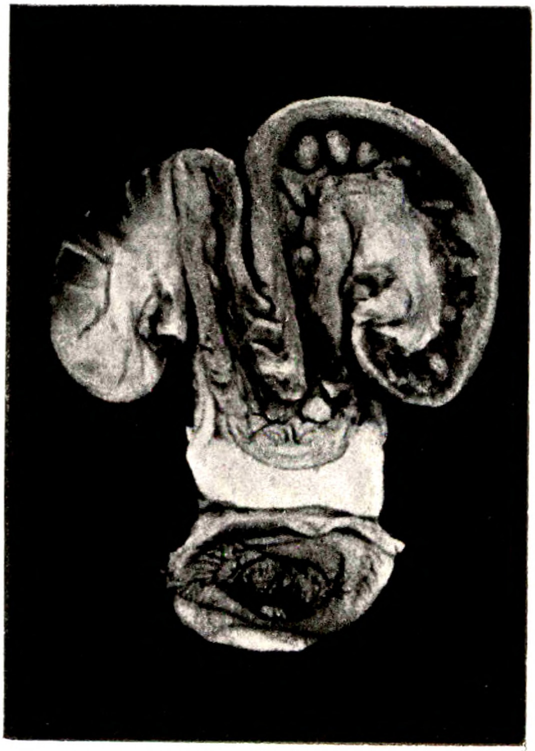


Fig. 19—Haematometra cum pyometra, showing the blood and pus filled condition of the uterus developed after abortion and retention of the placenta.

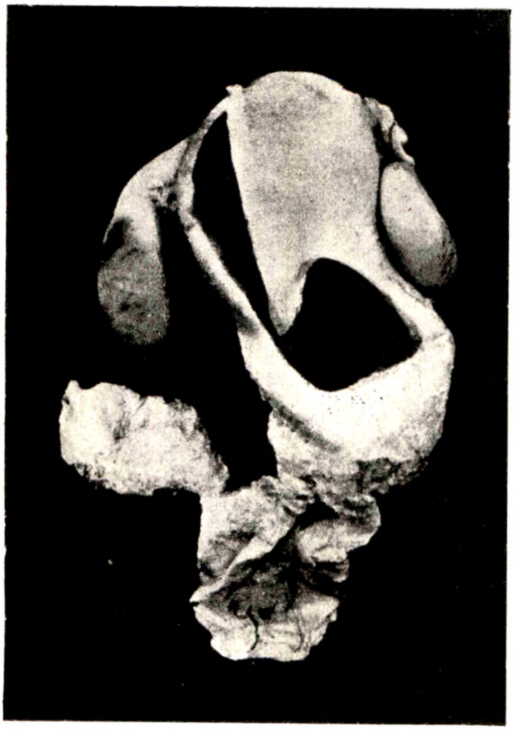


Fig. 20—Physometra, showing the dialated gas filled condition of the uterus without caruncles and with wide uterine corpus. The congested cervix and vagina is also seen.

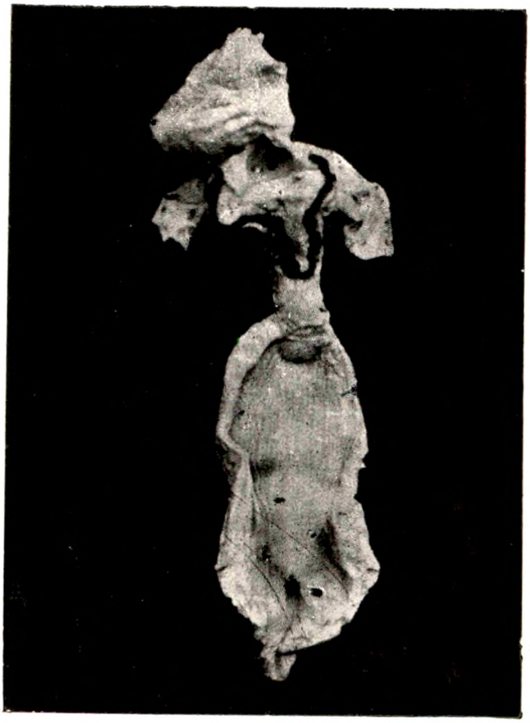


Fig. 21—Uterine abscess, showing the pus pool between the two uterine horns shown in black. The structure on the top of the figure is the urinary bladder to which it was fused.

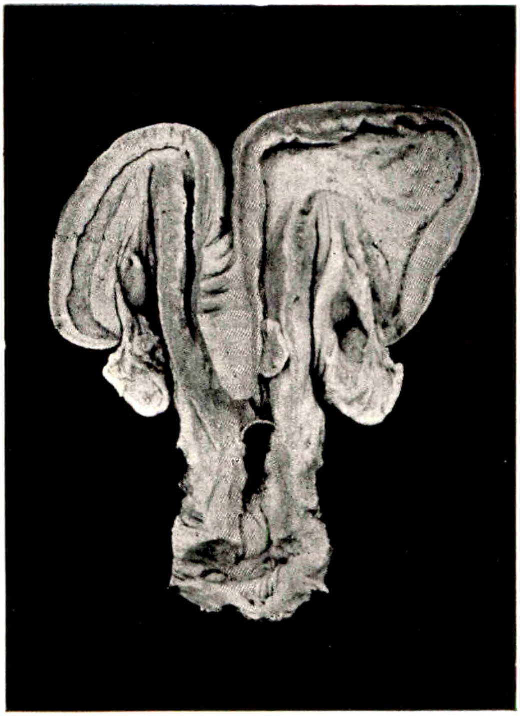


Fig. 22—Septic mummy, showing the well marked foetal site containing pus and foetal bones in the right horn.

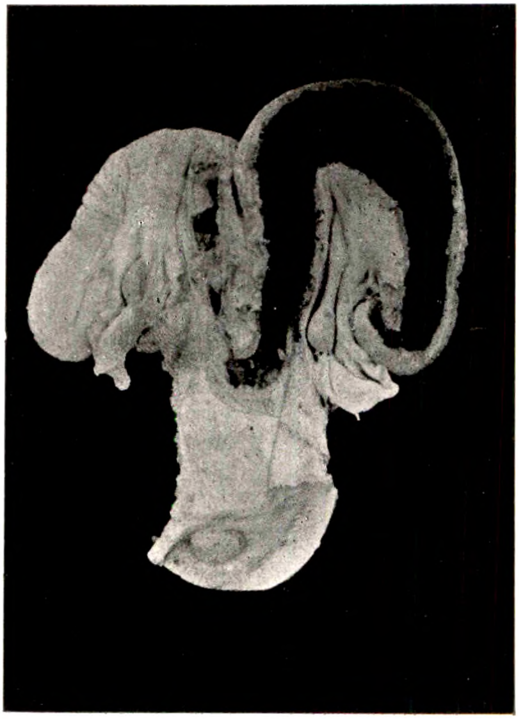


Fig. 23—Aseptic mummy, showing the aseptic condition of the dead foetus in the right horn.

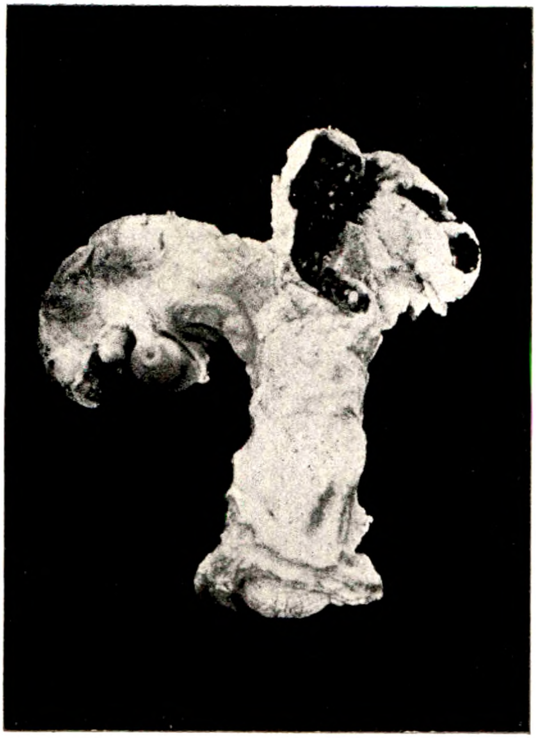


Fig. 24—Blind horn, showing the transverse septa running across the lumen of the horn.

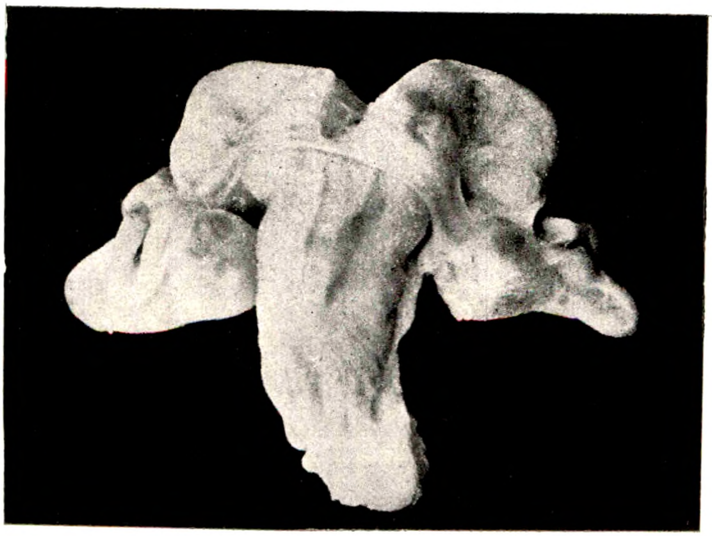


Fig. 25. Bilateral hydrosalpinx, showing the fluid filled Condition of the fallopian tubes and peritoneal adhesions.

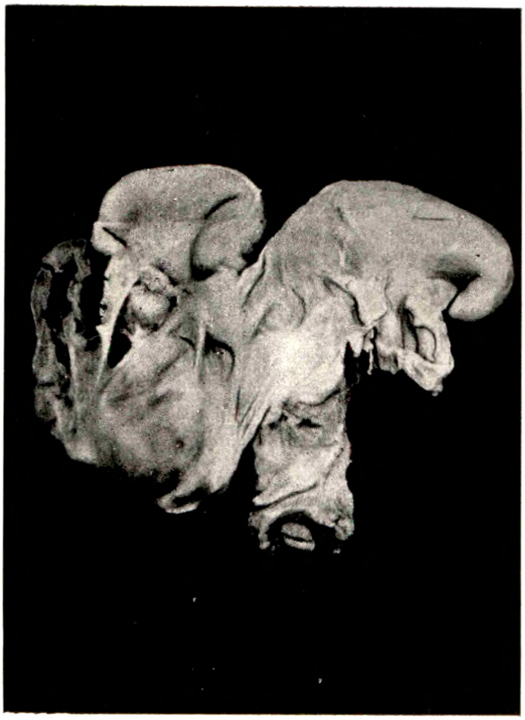


Fig. 26—Unilateral hydrosalpinx, showing the fluid filled condition of the fallopian tube and peritoneal infection and adhesions.

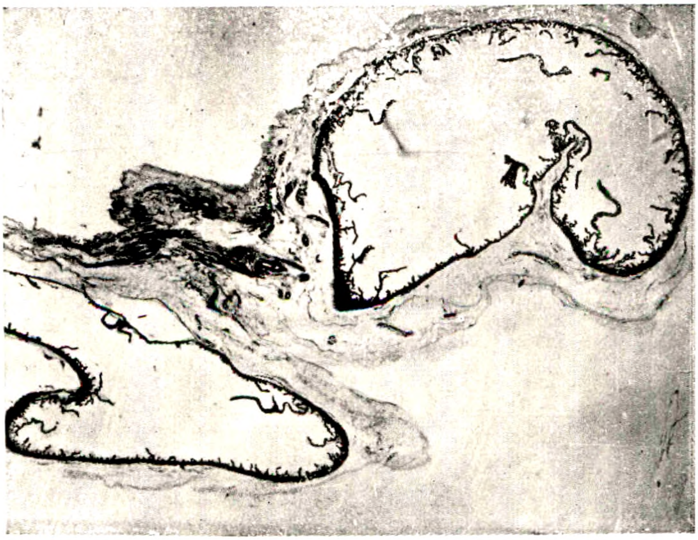


Fig. 27—T. S. of the fluid filled fallopian tube showing the pressure atrophy of the inner mucosa.

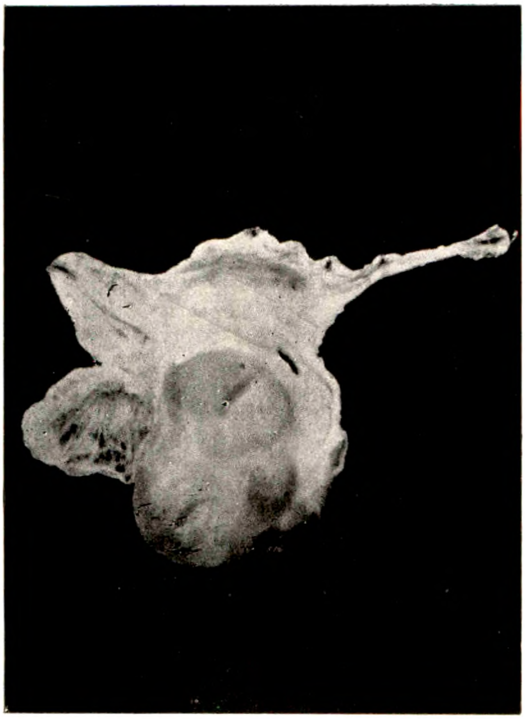


Fig. 28.

Fig. 28 & 29—Cystic ovaries, showing the enlarged thin walled follicles.

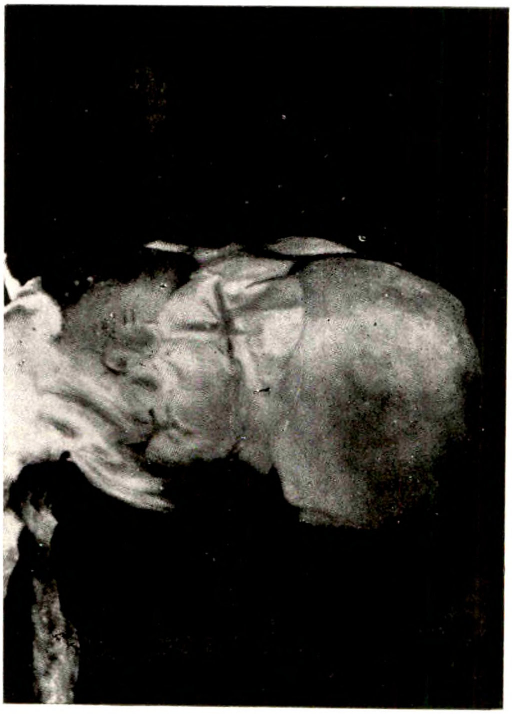


Fig. 29.

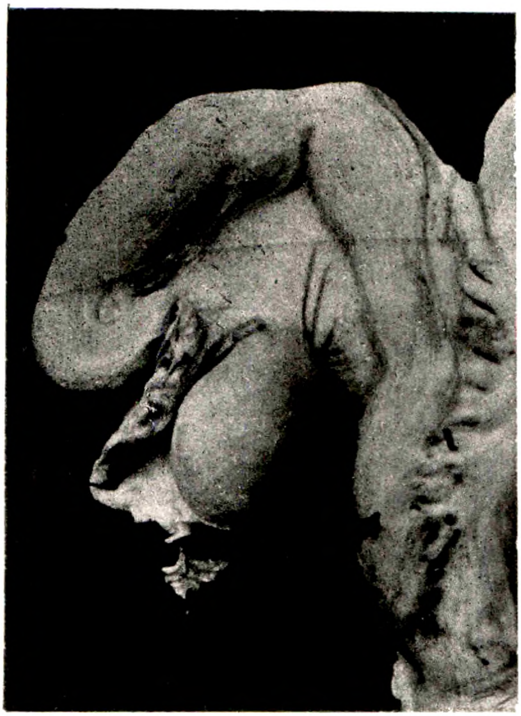


Fig. 30—Genitalia with thick walled cystic ovary.

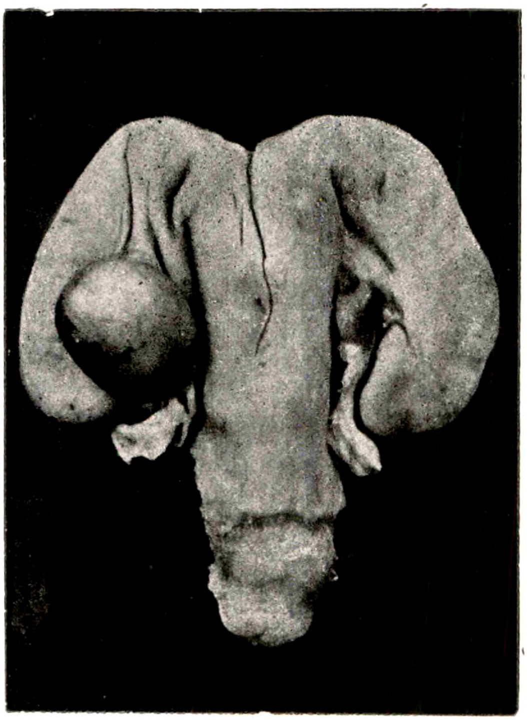


Fig. 31—Genitalia with tumorous ovary due to dermoid cyst.

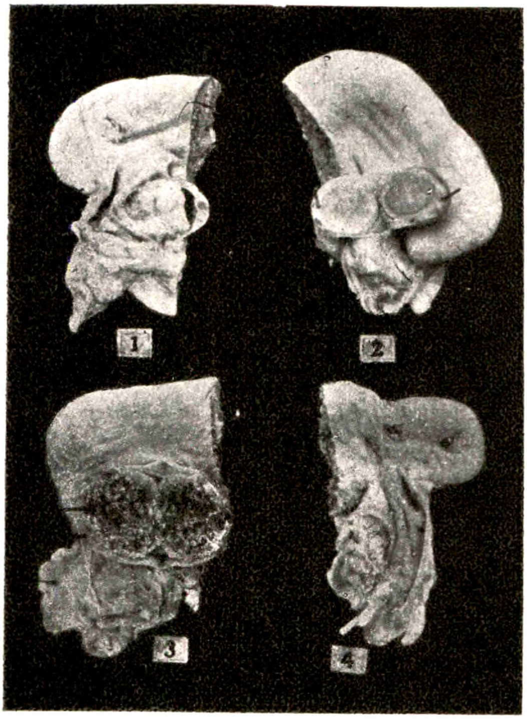


Fig. 32

Fig. 33

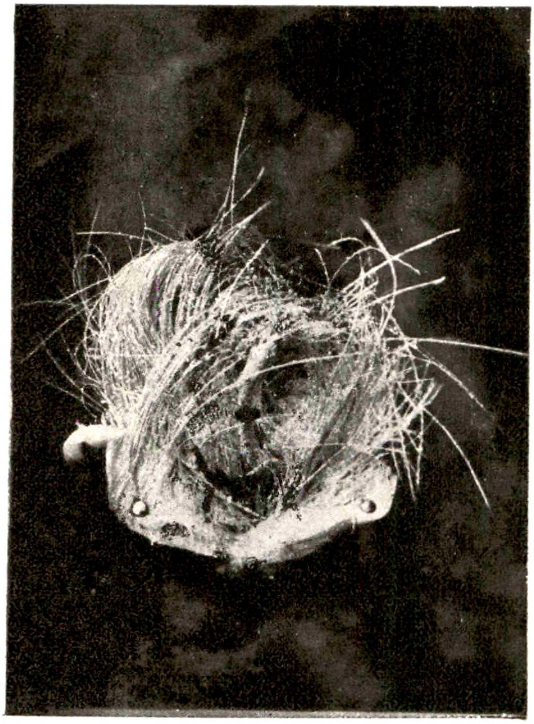


Fig. 32 & 33—Ovarian dermoid cysts of various kinds.

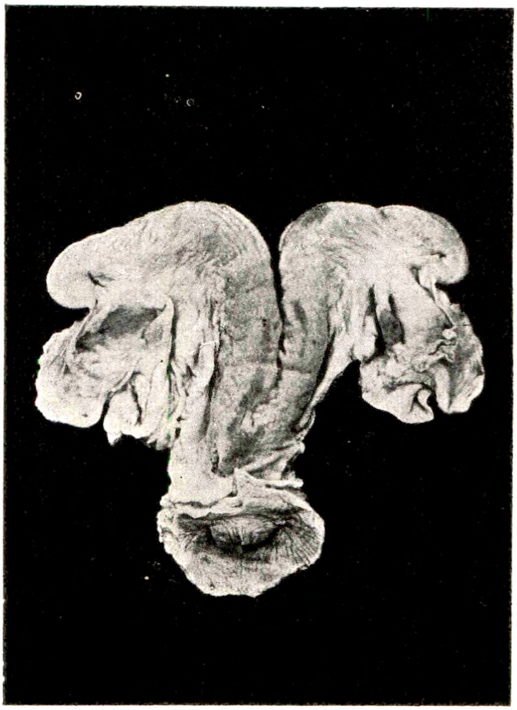


Fig. 34—Subnormal genitalia with hypoplastic ovaries

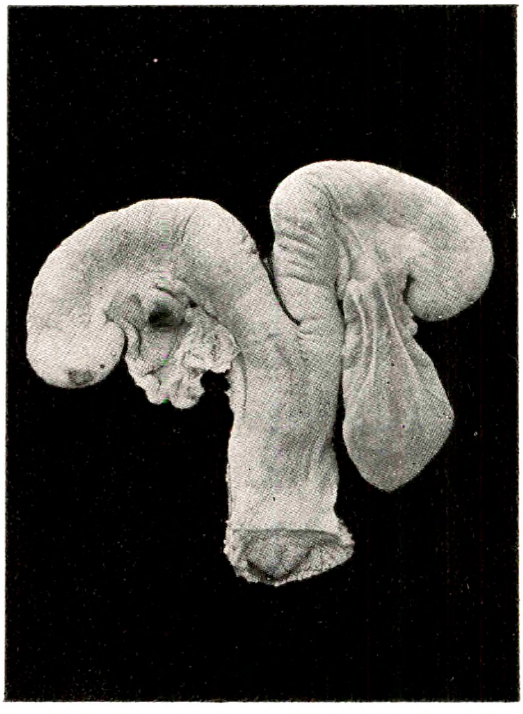


Fig. 35—Genitalia showing peri-oophoritis and the peri-oophoritial bag.

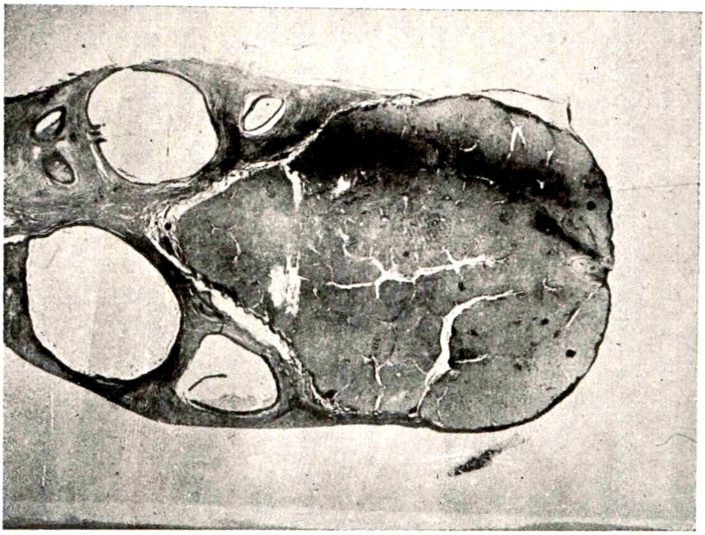


Fig. 36—T. S. of the ovary with persistent corpora and atretic follicles.

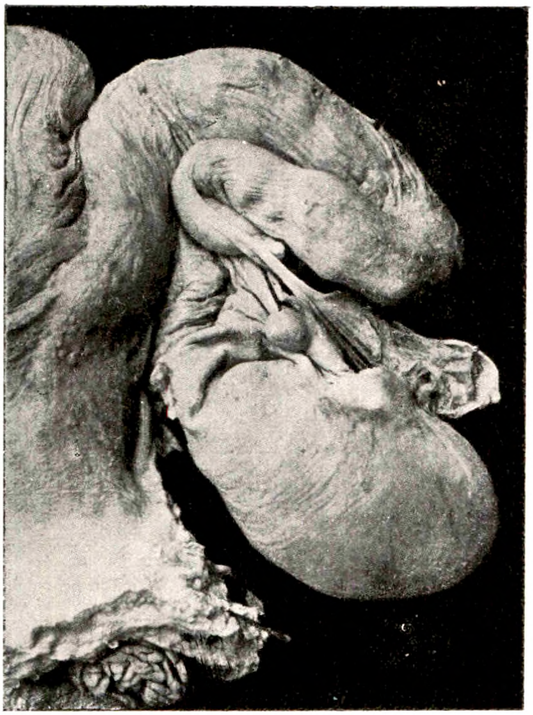


Fig. 37—Genitatia, showing the fluid cyst of the broad ligament.

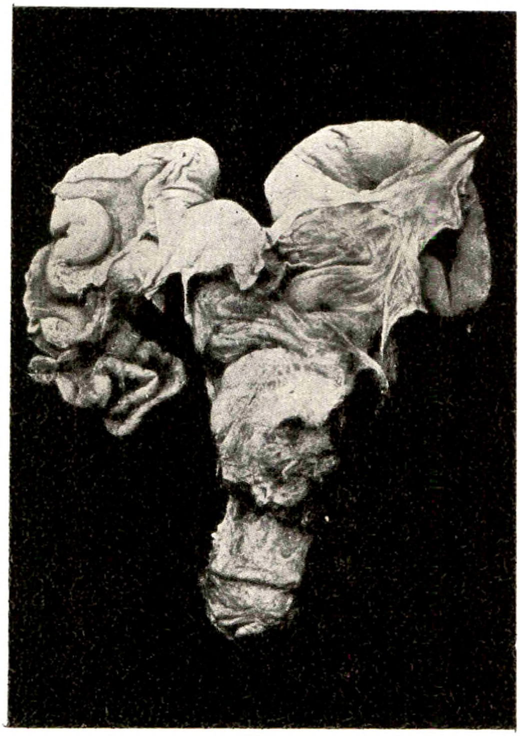


Fig. 38—Genitalia showing the infection of the peritoneum leading to severe peritonitis.

STUDIES ON THE CRANIAL OSTEOLOGY OF INDIAN CLUPEOID FISHES

II. The Skull of *Coilia dussumieri* C. V.

Jagdish Chandra Moona,
Ramjas College, University of Delhi, Delhi.

Introduction

Very little work has been done on the osteology of clupeoid fishes. The accounts available are from Ridewood (1904) on a number of British clupeoid fishes and from Joshi and Bal (1953) on the skull of *Coilia dussumieri.* Recently the skull of *Hilsa ilisha* (Ham.) has been described by the author (1959) with a view to study the cranial osteology of Indian clupeoid fishes. The present paper is the second in series and embodies a brief description of the skull of *C. dussumieri,* which showed a number of differences from the earlier account of the fish.

Material and Methods

C. dussumieri is a marine fish, available in abundance from Bombay waters. For the osteological study, fresh specimens of the fish were obtained from Sassoon Dock, Bombay and were brought to the research laboratory of the Taraporewala Aquarium, Bombay, for preliminary investigations. A few specimens, preserved in formalin, were brought to the Zoology laboratory of Ramjas College, Delhi for further study.

In the preliminary investigation, the heads of fresh specimens of the fish were severed and subjected to boiling water. The muscles were removed carefully and bones studied under the binocular dissecting microscope. A rough description of various bones and their articulation was noted down. In further study, alizarin transparencies were prepared of the formalin preserved specimens and the bones were restudied to confirm the earlier findings. The sketches were drawn with the help of a camera lucida.

Observations

Cranium

The cranium of *C. dussumieri* is devoid of spinous outgrowths from the hind end and hence this end is smooth and ovoid in appearance. A characteristic ethmoid crest, in front takes part in the formation of the projecting snout. The absence of the temporal fossae, preepiotic fossae, posttemporal fossae and auditory fenestrae is noteworthy. The parasphenoid is not winged and terminates soon after joining with the anterior end of the basioccipital. The myodome the eye muscle canal is therefore reduced and is formed only by the prootics and the parasphenoid, the basioccipital taking no share in its formation.

The ethmoidal region :

The ethmoid (mesethmoid) projects much in advance of the vomer. Dorsally it bears a median crest, which forms the nasal septum and runs forward into a pair of ethmoid cornu. Behind, the bone is overlapped by the frontals and laterally articulates with the lateral ethmoids. From its either side arises a projection for the articulation to the maxilla. Ventrally it is deeply grooved for the vomer. The ethmoidal fontanelle observed in *Hilsa ilisha* (Ham.) is absent. The lateral ethmoids (ectethmoids) are laminate and curving in front, form the anterior boundary of the orbits. The curved ends of the two lateral ethmoids meet over the parasphenoid. Articulating with the ethmoid and frontal, the bone bounds the olfactory fenestra for the olfactory nerve. The vomer is triangular in form with the base articulating below the ethmoid and apex lying beneath the front end of the parasphenoid. It is edentulous and grooved below. The nasals are small scale-like bones attached to the two sides of the ethmoid crest by muscles. Lying above the lateral ethmoid, each forms the inner boundary of the nasal sac, the outer boundary being formed by the first supraorbital.

The temporal region :

The frontals roof over the cranium and overlap the parietals, supraoccipital, sphenotics and prootics. Over each frontal is a pair of thin transverse bridges, one behind the other, which support the muscles. The front bridge is complete while the hind one is incomplete. The parietals are small triangular bones, articulated to the sides of the supraoccipital. The two parietals are separated from each other by the intervention of the supraoccipital. Each bone is produced upwards and backwards into a free wing-like process.

The pleurosphenoids are flat squarish bones, which form the anterior boundary of the brain case. The two bones enclose the optic foramen between them. The orbitosphenoid is a median bone, 'V'—shaped in cross-section. Its two dorsal edges are articulated to the frontals having no connection with the prootics. The bone does not reach the lateral ethmoid or the parasphenoid and fails to form the interorbital septum. The parasphenoid has no posterior wings and does not extend below the basioccipital. The usual ascending processes for the articulation with the prootic are wanting. In front the bone articulates with the vomer and behind with the anterior end of the basioccipital. The basisphenoid is absent.

The orbital region :

The circumorbital ring is incompletely formed of two supraorbitals, five suborbitals and a lacrymal. The first supraorbital is small and irregular and bounds the nasal sac on the outer side. The second supraorbital is elongated and attached to the outer margin of the frontal. Through the suborbitals runs the infraorbital canal of the lateral line system, which terminates in the lacrymal.

The otic region :

The prootics are large and formed into cups into which lie the lapillus of the internal ear in front and the vesicle of the swim bladder behind. The inward projections from the two prootics join and form a bridge over the myodome. The bone bears two apertures, one for the hyomandibular branch of the trigeminofacial complex and the other for the external carotid artery. The epiotics are triangular in shape, with their bases articulating in front with the supraoccipital. Each articulates with the pterotic, exoccipital and supraoccipital. The pterotics are large bulging bones on the outer sides of the epiotics. Each bone curves ventrally to meet the basioccipital. In front it articulates with the parietal and frontal and behind with the supraoccipital and exoccipital. The bone has a bulla for the vesicle of the swim bladder. The sphenotics are small triangular bones attached to the anterior upper end of the prootics. It forms along with the prootic, a depression for the articulation to the head of the hyomandibula. The opisthotic is absent.

The occipital region :

The supraoccipital is triangular in form with its base directed in front to meet the frontals. The apex fits between the two exoccipitals but takes no part in the formation of the foramen magnum. The expanded exoccipitals form most of the posterior portion of the cranium and alone bound the foramen magnum. Each bears apertures for the glossopharyngeal and vagus nerves. The basioccipital neither has depressions above for the otoliths nor a groove for the eye muscle canal below. It is somewhat triangular in form with its flat basal edge articulating in front with the parasphenoid and prootics. The apex is thickened behind forming the occipital condyle. The entire bone is firmly held between the exoccipitals.

Visceral Skeleton

The opercular series :

In the opercular series the interopercular is the smallest. The subopercular lies overlapped by the lower edge of the opercular and hind edge of the interopercular. The preopercular overlies the opercular, hyomandibula, subopercular and interopercular.

The maxillary series :

The upper jaw comprises small premaxillae and large maxillae, which are toothed. The maxilla forms the major part of the gape of the mouth and terminates a little before reaching the opercular margin. Its posterior end is pointed and supports a pair of supramaxillaries. The maxilla articulates with the lateral process of the ethmoid by its inwardly directed facet and with the premaxilla by the facet at its anterior end. A little behind the anterior facet is another facet for the palatine. The premaxillae of both the sides articulate with the ethmoid, but do not join with each other. A pair of supramaxillaries lie one behind the other on the outer side of the maxilla. The second one lies attached to the ridge over the maxilla and extends forward to lie over the first, while the first lies in between the front part of the second supramaxillary and the maxilla.

The mandibular series :

The dentary and the angular (articular) form the lower jaw. The dentaries are toothed and meet in front into a symphysis. Posteriorly each dentary is notched to receive the angular. The angular has a facet behind for the quadrate. Through the lower region of the dentary and the angular, runs the mandibular branch of the lateral line system. The sesamoid angular and retroarticular are absent.

The suspensory series :

The axis of the hyomandibula is inclined posteriorly for the increased gape of the mouth. It articulates by a single head with the sphenotic and prootic. On the inner face of the bone is a large recess for the hyomandibular embrassure muscles and in it lies the aperture for the hyomandibular nerve. Behind, it bears a knob-like process for the opercular. A small symplectic is attached to the lower end of the hyomandibula and articulates with the quadrate.

The palato pterygo quadrate series :

The palatine is a flattened bone articulating in front with the vomer and lateral ethmoid and giving support to the maxilla of its side. Behind, it articulates with the entopterygoid and ectopterygoid. On its lower margin is a row of fine uniform teeth. The entopterygoid is flap-like, with its upper part curved inwards to form the floor of the orbit. It is articulated with the palatine, ectopterygoid and metapterygoid and its inner margin reaches the parasphenoid. The ectopterygoid is elongated and its front half bears a row of teeth in continuity with those on the palatine. In front, it articulates with the palatine and by its upper margin to the entopterygoid and quadrate. The metapterygoid is toothless and its upper part is curved inwards to form the floor of the orbit. It articulates behind with the hyomandibula and below with the quadrate. The articulating facet of the quadrate is turned backwards in correlation with the enlarged gape of the mouth. Dorsally, the bone bears a notch for the articulation to the symplectic.

The hyobranchial series :

The epihyal is small and its proximal end bears a notched facet for the interhyal. Below, it gives articulation to the ten branchiostegal rays. The ceratohyal is long and articulates distally with a pair of hypohyals. Below it, is attached a pair of branchiostegal rays. The upper hypohyal is small and triangular and is firmly attached to the lower hypohyal. Its backwardly directed apex fails to reach the ceratohyal. The basihyal is absent and the hypohyals of the two sides meet in a symphysis in front. A long urohyal is present and its front end articulates below the hypohyals. Of the twelve branchiostegal rays, the last one is laminated while the remaining are curved rods.

In the absence of the basihyal, the first basibranchial articulates with the upper hypohyals. The second basibranchial is slightly longer than the first while the third is very small. The fourth basibranchial is represented by a cartilagenous rod. All the basibranchials are covered over by a dentigerous sheath. The first hypobranchials are long and the second and third become gradiently smaller. The third hypobranchials clasp the hind end of the third basibranchial and meet below it. The fourth hypobranchials are unossified.

The first ceratobranchials are comparatively more curved than the second pair. The third and fourth pair of them are nearly straight. The fifth pair of ceratobranchials which represent the entire arch are broad in front and bear a set of teeth on the inner margin. The hind ends of the fourth and fifth ceratobranchials join through cartilages and together articulate with the fourth epibranchial. Of the epibranchials, the fourth is stouter and broader than the rest. The first pair of pharyngobranchials are small rod-like bones, suspending the branchial skeleton from the prootics. Other pharyngobranchials are pointed in front and are placed one behind the other, giving articulation to the respective epibranchials from the sides. The pharyngobranchials of the two sides remain apart and do not form the pharyngobranchial rod as in *Hilsa ilisha*.

DISCUSSION

On comparing the observations with the account of the skull of *C. dussumieri* given by Joshi & Bal (1953) and with the account of *C. nasus* given by Ridewood (1904), a number of differences have been noticed. The ethmoid bears a median crest, which gives a pair of ethmoid cornu. The olfactory fenestra is bounded by the ethmoid, lateral ethmoid and frontal. The cornua have not been described by the previous authors and the olfactory fenestra according to Joshi and Bal, is bounded by the lateral ethmoid and ethmoid only. The vomer in *C. dussumieri* is toothless while teeth have been reported in *C. nasus* by Ridewood. The nasal lies above the ethmoid and forms the inner boundary of the nasal sac. It has not been possible to confirm the findings of Joshi and Bal, of its presence lateral to the frontal.

The circumorbital ring is formed of two supraorbitals, five suborbitals and a lacrymal. The first supraorbital forms the outer boundary of the nasal sac and the second lies behind it, lateral to the frontal. Joshi and Bal have made no mention of the supraorbitals and the second supraorbital has been designated by them as nasal. Ridewood no doubt described the two supraorbitals attached beneath the nasal sac and firmly attached to the lateral ethmoid (prefrontal). The remaining orbitals have been described as three suborbitals and three postorbitals in both the accounts. In conformity with the nomenclature of de Beer, the three postorbitals and two suborbitals of the previous authors, have been described as suborbitals and the anterior most, on which the infraorbital branch of the lateral line system terminates, has been termed as lacrymal.

The sphenotic is articulated with the limb of the frontal and prootic. Joshi and Bal have described the sphenotic attached to the prootic only and Ridewood called it as postfrontal. Following de Beer (1937), sphenotic has been considered the proper name for the bone. Joshi and Bal have described the sphenotic as well as the postfrontal separately in their account. The prootic and pterotic bones bear bullae for the vesicles of the swim bladder. The two bullae have not been desceribed by Joshi and Bal, although Ridewood has made a mention of their presence in *C. nasus*.

The frontal sends out a flap-like limb towards the outer side, which has been erroneously identified as postfrontal by Joshi and Bal. The parietals come nearer to each other and are not as much apart as in other clupeids, yet they are quite separate. Joshi and Bal have described the two bones almost meeting each other. The orbitosphenoid does not extend forward to meet the ethmoid, while Joshi and Bal have described an elongated process from its front end, which meets the mesethmoid (ethmoid).

The premaxillae are small triangular bones not meeting into a symphysis. Joshi and Bal have described them as short curved bones meeting each other medially. The maxilla fails to touch the posterior margin of the gill-cover and thus does not reach the gillopening, as has been described by Joshi and Bal. The two supramaxillaries of a side lie one behind the other on the outer side of the maxilla. The second supramaxillary is attached to the ridge in the posterior region of the maxilla, while the first supramaxillary lies between the second supramaxillary and the maxilla. Their position has not been clearly shown by Joshi and Bal and they have been described on the inner side of the maxilla. The subopercular lies below the opercular and the interopercular in front of the subopercular. Joshi and Bal have erroneously recognised the subopercular as interopercular and interopercular as subopercular.

Following the nomenclature of de Beer (1937), the articular is absent and the angular is present in fishes. As such the articular of Joshi and Bal may be interpreted as angular. The entopterygoid, which forms the floor of the orbit lying in front of the metapterygoid, has not been described by Joshi and Bal.

A pair of hypohyals have been noticed in each half of the hyoid arch. The first hypohyal has no connection with the ceratohyal but lies firmly attached over the second hypohyal. Joshi and Bal have failed to recognise the first hypohyal and have described only one hypohyal on each side. There are twelve branchiostegal rays, ten of which are articulated to the ceratohyal and the remaining two to the epihyal. The last ray is leaf-like while others are curved rods. Ridewood has described only eleven rays in *C. nasus*, eight of which are attached to the ceratohyal, the ninth to the junction of the ceratohyal and epihyal and the last two to the epihyal. Joshi and Bal have mentioned nine to ten dermal branchiostegal rays in relation to the ceratohyal. Neither the total number of rays has been given nor the number of rays attached to the epihyal has been indicated by them. The basibranchials are covered over by a thin dentigerous sheath and the fifth pair of ceratobranchials bear minute teeth. The facts have not been mentioned by Joshi and Bal.

The basisphenoid, opisthotic, preepiotic fossa, temporal fossa and auditory fenestra are absent. The projections from pterotic, sphenotic, epiotic and supraoccipital are also wanting. These features have not been put on record by Joshi and Bal.

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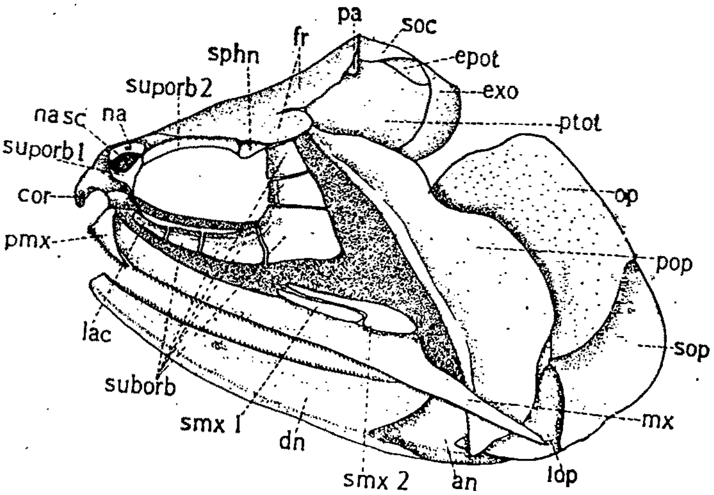
The skull of *Coilia dussumieri* C. V.

Fig. 1. Lateral view of the entire skull; Fig. 2. Dorsal view of the cranium; Fig. 3. Inner view of the opercular series, palato pterygo quadrate series and hyomandibula; Fig. 4. Hyoid arch and branchiostegal rays.

ahn., aperture for the hyomandibular embrassure muscles and hyomandibular nerve; *an.*, angular; *br.*, bridges over frontal; *brstg.*, branchiostegal rays; *cen.*, centrum of the basioccipital; *cerhy.*, ceratohyal; *cor.*, ethmoid cornu; *cr.*, ethmoid crest; *dn.*, dentary; *ecpt.*, ectopterygoid, *enpt.*, entopterygoid; *epihy.*, epihyal; *epot.*, epiotic; *eth.*, ethmoid; *exo.*, exoccipital; *fmg.*, foramen magnum; *fr.*, frontal; *frl.*, frontal limb; *hh.*, hypohyal; *hop.*, hyomandibular head for the articulation to the opercular; *hsphn.*, hyomandibular head for the articulation with the sphenotic-prootic depression; *hyom.*, hyomandibula; *ihy.*, interhyal; *iop.*, interopercular; *lac.*, lacrymal; *leth.*, lateral ethmoid; *mtpt.*, metapterygoid; *mx.*, maxilla; *na.*, nasal; *nasc.*, nasal sac; *op.*, opercular; *pa.*, parietal; *pl.*, palatine; *pmx.*, premaxilla ;*pop.*, preopercular; *ptot.*, pterotic; *qu.*, quadrate; *smx.*, supramaxillary; *soc.*, supraoccipital; *sop.*, subopercular; *sphn.*, sphenotic; *suborb.*, suborbital; *suporb.*, supraorbital; *syml.*, symplectic.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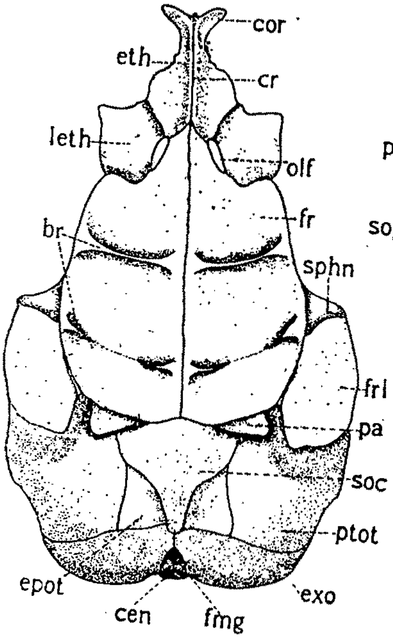
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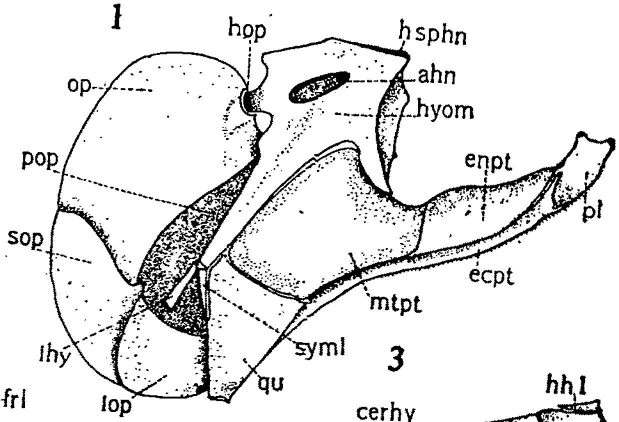
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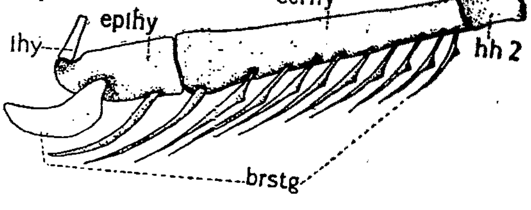
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ACTION OF CERTAIN REAGENTS ON *w*-DIAZO *w*-METHYL ORTHO METHOXY ACETOPHENONE AND *w*-DIAZO *w*-METHYL ORTHO ACETOXY ACETOPHENONE

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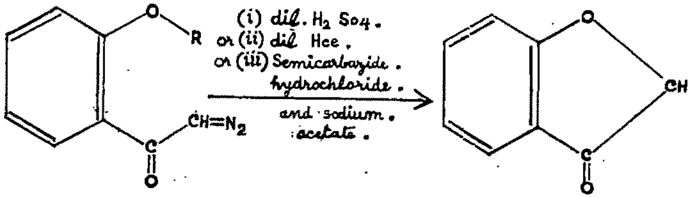
Clibbens and Nierstein[1] obtained coumaranone (I) from diazomethane (1 mole.) and ortho acetoxy benzoyl chloride (1 mole.) but the interpretations of the mechanism of the reaction that they gave were wrong. U.S. Seth and S. S. Deshapande[2] obtained coumaranone (I) from ω-diazo ortho acetoxy acetophenone (II) and Conc. $H_2 SO_4$. Marshall, Kuck and R. C. E. Elderfield[3] reported the formation of coumaranone (I) from *w*-diazo ortho methoxy acetophenone (III) and cold acetic acid. (I) was also obtained by A. K. Bose and Peter Yates[4] on treatment of ω-diazo *o*-methoxy acetophenone (III) with hydrochloric acid. A mechanism of the reaction has been discussed by Bose and Yates and also independently by Marshall and Walker.[5]

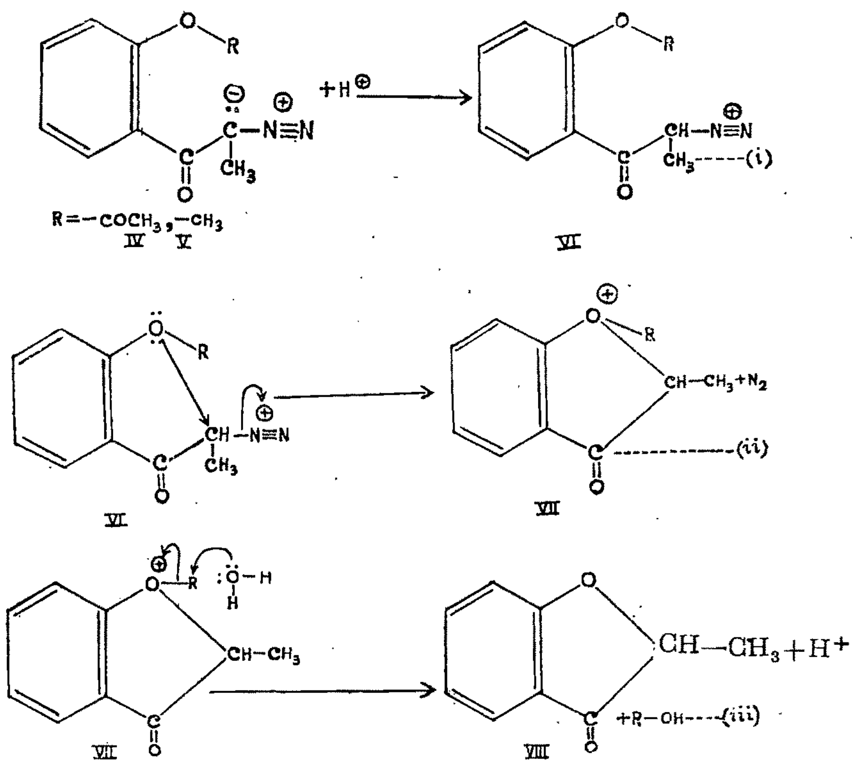


$R = -COCH_3, -CH_3$
II III

I

O-acetoxy benzoyl chloride and o-methoxy benzoyl chloride (each 1 mole) dissolved in dry ether were treated with an ethereal solution of diazo ethane (2.5 mols) at-10°C. After keeping the reaction mixture overnight at O°C and removal of the ether under reduced pressure, liquids were obtained which were expected to be diazo-ketones IV and V. The liquids failed to give Arndt and Eistert[6] reaction but formed semicarbazones having the same melting points namely 234°C and their mixed melting points were also the same. The liquids on treatment with dil. H_2SO_4 evolved nitrogen readily. When evolution of nitrogen ceased, the ether extraction gave liquids in both cases which gave semicarbazones on treatment with semicarbazide hydrochloride and sodium acetate. The semicarbazones from the two liquids also had the same melting point 234°C and their mixed melting point also did not show any depression, showing thereby that the semicarbazones were of one and the same substance.

The melting point and the results of analysis of the semicarbazone leave no doubt that it is of 2-methyl coumaranone (VIII). The formation of the same semicarbazone directly from the crude diazoketones IV and V and also from their decomposition products with dil. H_2SO_4, can be readily explained by the mechanism put forward by A. K. Bose and Peter Yates.



In reaction (i) a proton (from the acid) attacks the nucleophilic methine carbon to form an aliphatic diazonium ion (VI) which then loses nitrogen by a displacement reaction on carbon involving an unshared electron pair on oxygen (ii). The oxonium ion (VII) thus formed is then attacked by the solvent water to give methyl coumaranone (VIII) and R-OH (R=CH_3CO-, CH_3-). At the same time the proton is regenerated.

EXPERIMENTAL

ω-diazo w-methyl o-acetoxy acetophenone (IV)

O-acetoxy benzoyl chloride (8 g., 1 mole.) dissolved in dry ether, was slowly added to an ethereal solution of diazoethane prepared from 18.7 g of nitrosoethyl urea (the solution contained about 5.48 g 2.5 mols. of diazoethane). The temperature was maintained at-10°C and the addition spread over a period of 1 hour. Nitrogen was slowly evolved. The reaction mixture was kept at O°C overnight. The solvent was then removed by evaporation under reduced pressure. The crude diazoketone weighed 6 g. The crude diazoketone gave a semicarbazone m. p. 234°C.

ω-diazo ω-methyl o-methoxy acetophenone (V)

O-methoxy benzoyl chloride dissolved in dry ether (7 g 1 mole) was treated with ethereal solution of diazoethane (2.5 mols.) obtained from 17 g nitrosoethyl urea in the manner described above. The crude diazoketone weighed 6.5 g. The crude diazoketone gave semicarbazone m. p. 234°C.

Formation of Decomposition product by dilute H_2SO_4

The liquid diazoketones (IV and V) were dissolved in ether and separately treated with a few drops of dilute sulphuric acid. Brisk evolution of nitrogen took place which subsided after some time. Then the solutions were washed with water, dried and evaporated, when liquids were obtained in both cases. These liquids were then separately treated with semicarbazide hydrochloride and sodium acetate. Semicarbazones m.p. 234°C (V. Auwers describes m.p. of semicarbazone of 2-methyl coumaranone to be 234-235°C) were obtained (found C, 57.9%; H, 5.1%, N, 20.0%, $C_{10}H_{11}O_2N_3$ requires C, 58.53%, H, 5.36% and N, 20.4%).

Semicarbazones were also obtained by direct treatment of the liquid diazoketones (IV and V) with semicarbazide hydrochloride and sodium acetate. Both semicarbazones melted at 234°C.

A mixed melting point of the semicarbazones obtained in both of the above cases showed no depression.

ABSTRACT

ω-diazo ω-methyl orthomethoxy acetophenone and ω-diazo ω-methyl orthoacetoxy acetophenone on treatment with dilute sulphuric acid give 2-methyl coumaranone. This 2-methyl coumaranone gives a semicarbazone which is identical with that obtained directly from the two diazoketones.

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CONTENTS

PAGE

1. Study of Carbanion Formation in Ketones Through Synthesis and Reaction of Isonitroso and Nitroso Ketones. By O. N. PERTI and G. C. SINGHAL 167
2. Papyrographic Characterization of Non-Volatile Organic Acids in some Medicinal Plants of Naini Tal. By K. C. SAH and D. R. GUPTA 175
3. Kinetics of Oxidation of Ketones by Persulphate Ion. By K. C. KHULBE and S. P. SRIVASTAVA 177
4. Chromatographic Characterization of Amino Acids in some Common Vegetables of Naini Tal. By K. C. SAH and D. R. GUPTA 191
5. Physiological Studies on Salt Tolerance in Crop Plants. VII—Studies on Growth and Maturity of Wheat and Gram in Saline or Alkaline Areas in Cultivators' Fields. By S. N. BHARDWAJ 195
6. The Chlorophyceae of the Kumaon Hills, U. P., India—1. By KAMALA P. SINGH 211
7. Morphological Studies in Some Members of the Family Pedaliaceae. By SATYA PAL SINGH 217
8. Role of Potassium Deficiency in Surgical Patients ; its Recognition and Management. By H. L. KHANNA and S. P. SRIVASTAVA 221
9. Entomological Survey of the Himalaya. Part XXXI—New and Little Known Stoneflies (Plecoptera) from the North-West (Punjab) Himalaya collected by Prof. Mani's Third Entomological Expedition. By STANLEY G. JEWETT, JR. 229
10. A Complex Inversion Formula for a Generalized Stieltjes Transform. By SURESH CHANDRA ARYA 233
11. Studies on the Keeping Quality of Creamery Butter During Storage at 40° F. By N. N. PANDIT, R. S. RAWAT and S. N. SINGH 243
12. A Technique for Disease Appraisal and Loss Estimation in *Fusarium* Wilt of Gram (*Cicer arietinum* L.) By S. K. CHAUHAN ... 253
13. Studies on Comparative Utilization of Available Moisture by Sal (Shorea Robusta) and Some Associated Weed Species. By HARISH P. BHATNAGAR 261
14. Structure and Abnormalities of the Female Ganitalia in Indian Buffalo. *Bos (Bubalus) bubalis* L. By P. S. MALIK, O.P.S. SENGAR and S. N. SINGH 271
15. Studies on the Cranial Osteology of Indian Clupeoid Fishes. II—The Skull of *Coilia dussumieri* C. V. By J. C. MOONA ... 313
16. Action of Certain Reagents on *w*-Diazo *w*-Methyl Ortho Methoxy Acetophenone and *w*-Diazo *w*-Methyl Ortho Acetoxy Acetophenone. By R.P. KAPOOR, P.B.L. KAPOOR and S.M. GUPTA 323

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